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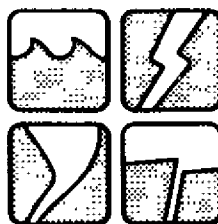
**REGULATION OF
FLOOD HAZARD AREAS
TO REDUCE FLOOD LOSSES
VOLUME 3**



Prepared for the U.S. Water Resources Council

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TO REDUCE FLOOD LOSSES
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**Jon A. Kusler
Attorney at Law**



Natural Hazards Research and Applications Information Center
Special Publication 2

Program on Environment and Behavior
Institute of Behavioral Science
University of Colorado
1982

REGULATION OF FLOOD HAZARD AREAS TO REDUCE FLOOD LOSSES, VOLUME 3

Prepared for



The U.S. Water Resources Council
Washington, D.C.

The opinions contained herein are those of the author and do not necessarily reflect the views of the U.S. Water Resources Council or its member agencies.

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FOREWORD

The U.S. Water Resources Council contracted for this report to update and supplement Volumes 1 and 2 of Regulation of Flood Hazard Areas to Reduce Flood Losses which were prepared and published by the Council between 1968 and 1971. Volume 3 reviews accomplishments and problems of the decade of the 1970s in the use of floodplain regulations as one element of floodplain management. It suggests strategies for the 1980s for improving the quality of regulations and for combining regulations with other management tools to serve multipurpose state and local goals.

As a supplement to Volumes 1 and 2, this report does not repeat earlier materials. The reader is assumed to be familiar with basic floodplain management concepts. Emphasis in this volume is on conclusions drawn from the experience of the 1970s and new directions for the 1980s.

The report was prepared for the Council by Dr. Jon A. Kusler, an attorney and specialist in water resources systems, working under the guidance of an interagency task force. He is uniquely qualified to carry out this task, having been principally responsible for the research and writing of Volumes 1 and 2, and as the author of many studies on floodplain management during the last decade. The opinions expressed herein are those of Dr. Kusler.

We hope you find the report useful and interesting.



Frank Thomas
Acting Director,
U.S. Water Resources Council

PREFACE

Volume 3 documents progress and problems with floodplain regulations in the 1970s and suggests strategies for the use of regulations as part of broader floodplain management efforts in the 1980s. Its focus is on state and local programs, including innovations that can serve as examples for effective flood loss reduction in the 1980s.

Preparation of Volume 3 began with surveys of state and local floodplain regulations and court decisions during the 1970s to document progress and to identify problems. The surveys revealed that the materials contained in Volumes 1 and 2 of Regulation of Flood Hazard Areas to Reduce Flood Losses including model statutes and ordinances and legal analyses, are generally applicable to the 1980s. Volume 3, therefore, is designed to supplement and update rather than replace earlier materials, with an emphasis on increasingly effective floodplain management.

Material from the two surveys has been assembled and published as two separate appendices: Strengthening State Floodplain Management and Innovation in Local Floodplain Management. Volume 3 cites and draws upon both.

The report and appendices are based upon both primary and secondary sources of information. Preparation began with the review of papers and presentations from a series of eight floodplain and wetland seminars conducted by the U.S. Water Resources Council during the winter of 1978 and the spring of 1979. The seminars dealt with problems, issues and opportunities in floodplain and wetland management. See Kusler (1979). This assimilation was followed by a review of other publications issued since 1970 dealing with floodplain management. (See the bibliography of this report and the appendices for a partial listing.) Contacts were also made with other studies underway including one conducted by the National Science Foundation for Congress in 1980 which produced an excellent

document, A Report on Flood Hazard Mitigation. Since the goal of the present report was to distill a decade of research and experience concerning the status, problems and possible new approaches for floodplain regulations, considerable use was made of this and other studies. Not surprisingly, conclusions of the present study closely parallel those of the National Science Foundation.

After completing the literature review, several independent surveys were conducted. These included (1) a survey of all state floodplain programs, carried out by the Association of State Floodplain Managers; (2) interviews with approximately 300 local government officials, state program personnel, regional personnel of FEMA, and the Corps of Engineers; (3) a search and analysis of court cases since 1970 which have litigated federal, state and local floodplain regulations; and (4) preparation of case study profiles for 150 communities with innovative floodplain management programs.

These surveys helped test conclusions and recommendations from other studies and provided new information concerning innovative approaches but fell short of field documentation of flood hazard mitigation approaches. Limited data concerning the type and characteristics of new and existing floodplain structures; flood losses to unprotected, partially protected structures; the effectiveness of specific types of flood mitigation measures; and compliance of new structures with regulations prevented a thorough analysis of regulations. It is hoped that the Federal Emergency Management Agency, the U.S. Army Corps of Engineers, the National Science Foundation, the states, and other organizations will help gather such data over the next decade to test the conclusions of this and other reports.

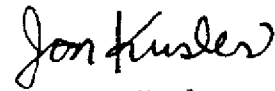
In the synthesis of material, several conclusions were particularly compelling:

- 1) The overall floodplain mapping, regulatory, acquisition, insurance, and other management approaches applied at the state and federal levels during the 1970s have stimulated large numbers of strong community floodplain management programs. Now the challenge is to address the more unique flood problems which face thousands of additional communities.
- 2) Flooding will continue to be a major national problem with periodic losses of hundreds of lives and billions of dollars in property damage when major hurricanes and inland storms occur. Despite the substantial progress in nonstructural floodplain management made during the 1970s, full implementation of flood loss mitigation measures is still far away, particularly for existing uses. Implementation will require continued federal leadership through partially subsidized insurance, disaster assistance conditioned upon mitigation measures, and floodplain acquisition and flood control measures on a cost-sharing basis. This should take place within a framework of consistent overall federal standards. States, communities and the private sector may bear a larger burden but the shift from total federal responsibility to greater state, local and private responsibility will take time. A careful system of incentives and disincentives is needed.
- 3) Floodplain management has become a technical subject as the approaches for floodproofing, flood warning systems, postdisaster mitigation, specialized regulation, and acquisition and relocation have been perfected. Increased expertise and education at all levels of government and in the private sector are needed to apply the lessons of the 1970s to the 1980s and to develop still more new approaches.

ACKNOWLEDGMENTS

Appreciation is expressed to all who participated in these efforts with particular attention to Pat Bloomgren, Larry Larson, and Marguerite Whilden, who provided information on state programs; Rutherford Platt for the excellent overall advice and discussion of legal issues; Frank Thomas and Tim Maywalt of the U.S. Water Resources Council for their help and guidance throughout the study; and Jacquelyn Monday of the Natural Hazards Research and Applications Information Center, University of Colorado, for her editorial assistance and patience in supervising publication of the manuscript. Special thanks is also due the Water Resources Council Work Group which provided able guidance throughout the project, including:

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EXECUTIVE SUMMARY

Progress in Floodplain Management

During the 1970s, many factors contributed to the growth and testing of floodplain management at all levels of government. Record floods took over two thousand lives and cost billions of dollars in property damage and government flood relief. Inflation soared and tax revenues dwindled. Courts increasingly held landowners, developers, subdividers and local governments liable for flood damages. This combination of losses, diminished revenues, and growing liability prompted Congress, the states and local governments to develop a federal/state/local partnership to cost-effectively reduce flood losses. Floodplain management took its lead from the fiscally sound recommendation of the 1966 Federal Flood Control Task Force: "Those who occupy the floodplain should be responsible for the results of their actions." Federal, state, and local governments strengthened their programs to assist disaster victims while redoubling their efforts to break the cycle of loss, repair, and subsequent loss. Programs were redirected to prevent losses from future uses of the floodplain and to reduce the flood damage potential of existing uses after the disaster.

Governments made substantial progress in establishing coordinated minimum flood standards for new development in floodplains and for redevelopment in damaged areas. The 100-year flood standard helped to coordinate federal, state and local mapping, standard-setting, flood-proofing, regulation, and other programs. Floodplain management programs were designed in many instances not only to reduce flood losses within the 100-year floodplain but also to serve broader goals. Implementation was often achieved through a combination of public education, regulation, acquisition, public facilities planning, and flood insurance. Regulations

were adopted to prevent floodplain occupants from increasing flood heights and velocities on other lands, victimizing unwary buyers, or constructing damage-prone structures. The reduction of public expenditures for federal and state disaster assistance and flood control measures was another goal. These regulations were overwhelmingly endorsed by the courts.

Federal Actions

Congress and federal agencies such as the Water Resources Council (WRC), the Federal Emergency Management Agency (FEMA), and the Office of Management and the Budget (OMB) made considerable progress in developing a coordinated federal policy to reduce future flood losses to public and private land uses. Nonstructural solutions were one component of that policy. Important federal actions during the decade were:

- The National Flood Insurance Program was expanded to almost two million policies and its coordination with disaster assistance programs was improved. Local governments were required to adopt land use control measures to reduce potential flood losses as a condition to obtaining federally subsidized flood insurance.
- Planning for disaster preparedness and postdisaster response increased. Disaster assistance benefits were increased, on condition that the recipients apply for flood insurance and adopt flood hazard mitigation measures.
- Guidelines for public uses and coordination of federal floodplain management were strengthened by adoption of the Floodplain Management and Wetland Protection Executive Orders (E.O. 11988 and 11990). These require that federal and federally sponsored projects avoid floodplains unless no alternative exists.
- Approximate flood hazard maps were developed for the entire nation. More detailed maps were developed (or are being developed) for 11,000 of approximately 20,000 flood-prone communities.
- The U.S. Army Corps of Engineers, the Soil Conservation Service, FEMA, and other agencies enhanced their provision of technical assistance to states, localities, and private landowners.
- State floodplain management was strengthened by financial and technical assistance from FEMA and WRC and through the Coastal Zone Management Program.

- Congress adopted new resource management programs with hazard reduction as a part of broader goals. The Coastal Zone Management Act of 1972 includes a system of grants-in-aid to the states. Section 404 of the Water Pollution Control Act Amendments of 1972 and 1977 provided more comprehensive federal control of discharges into rivers, lakes, and streams, including adjacent wetlands. Other resource protection measures that include hazard reduction components are grants in aid to states and communities for open space protection, wetland acquisition, and urban renewal.
- Congress and the agencies placed greater emphasis on nonstructural solutions including acquisition, regulations, flood-proofing, and flood warning systems. More consistent cost-sharing policies were also developed.

State Programs

States assumed a pivotal role in coordination, education, technical assistance, and setting standards in the 1970s.

- All 50 states appointed a flood insurance program coordinator to help communities enroll in the NFIP and to provide technical assistance on flood loss reduction.
- Seven states adopted new floodplain regulation programs, adding to the 24 states that had regulatory statutes in 1970. Others strengthened existing programs to establish standards for local regulations or to regulate directly flood hazard areas through permit systems, subdivision review requirements, or building codes.
- State legislatures increased the staff size and budgets of some state programs to accelerate mapping, increase technical assistance, and facilitate evaluation of permits.
- Many states adopted resource conservation statutes with hazard reduction as one objective. Four inland states and 11 coastal states adopted wetland protection legislation. Most coastal states established coastal zone management programs, some stressing hazard mitigation. Hazard mitigation was emphasized also in some wild and scenic river and subdivision review programs.
- Many states combined regulatory and nonregulatory floodplain management measures to serve multipurpose goals, including urban renewal and resource management as well as flood loss reduction. These measures included acquisition, flood warning systems, marking of flood hazard areas, and education.

Local Programs

In one sense, the most important nonstructural floodplain management programs of the 1970s were adopted by cities, counties, villages,

and towns. Most nonstructural measures were implemented at the local level.

- At least 17,000 communities adopted floodplain regulations or expressed the intent to adopt such regulations in order to enroll in the National Flood Insurance Program. Most local programs were consistent with minimum NFIP standards, and some went beyond them. Community awareness of flood problems and expertise to deal with the problems generally increased, although some communities are still deficient in both.
- Several thousand communities adopted wetland protection regulations, shoreland zoning, coastal zone management, prime agricultural land zoning, or other water and land resource management programs incorporating flood loss reduction as one objective.
- Many communities combined regulations with acquisition, flood warning systems, public education, and flood control works to reduce losses to both existing and new uses and to serve broader community objectives. Communities often adopted these innovative programs as part of multipurpose land management programs.

Problems with Implementation

Despite progress in guiding new structures to flood-free sites and establishing standards for new and existing structures in hazard areas, problems in implementing consistent flood loss reduction policies occurred at all levels of government. Few measures initiated in the 1970s were used to their full potential.

Major problems included:

- Regulations were only partially effective in many of the 12,000 "emergency program communities" that adopted or stated the intent to adopt regulations to qualify for the NFIP. The problem was due to lack of maps showing 100-year flood elevations, of ordinances that were legally enforceable, and of administrative staff in numbers sufficient to enforce compliance. These problems were particularly severe in rural areas.
- NFIP flood studies and map scales, levels of accuracy, and types of data were often partially inadequate for regulation, acquisition, and other site-specific floodplain management because they were developed to meet insurance rather than land use management needs. Maps failed to account for waves, water velocities, erosion, and watershed development, thereby showing underestimated hazards. Flood studies identifying the 100-year flood elevation were available for only one-half of the communities. Moreover, flood maps showing floodways and

coastal wave impact areas were available for a smaller number. Procedures for storing map data were thoroughly inadequate and, unless revised, threaten much of the federal investment of over \$500 million in mapping.

- Local governments and some state agencies lacked staff expertise to evaluate how individual permits would affect flood flows. Neither were agency personnel able to monitor or enforce state and local floodplain regulations.
- State and local regulations were relatively ineffective in reducing losses to existing uses except immediately after flood disasters.
- Some floodplain regulations were insufficiently tailored to flood characteristics such as fluctuations of water levels along lakes, high velocity flow areas in mountains, and combined storm surge and wave action in coastal areas.
- Floodplain regulations were often poorly coordinated with other resource protection regulations and comprehensive zoning and planning.
- Federal subsidies for flood control works, disaster assistance, flood insurance, and public works sometimes encouraged continued floodplain development or discouraged local government control of floodplain development and private damage reduction measures such as floodproofing.
- Court challenges to regulations continued, although very few were successful.

Strategies for the 1980s

The challenge for the 1980s will be the cost-effective implementation of flood loss reduction measures tailored to specific facts and circumstances within a continued overall set of national standards such as the 100-year flood standard. These measures should include preflood and postflood planning and incorporate regulations as one component. Implementation will require a federal and state political and financial climate that encourages local government and landowners to assume responsibility for flood loss reduction, and provides incentives for hazard mitigation tailored to local problems and needs. In addition to flood loss reduction, program emphasis, for cost effectiveness, should be on the protection of the quality and quantity of the nation's waters

and on conservation of critical floodplain resources such as farm lands. Tight budgets at all levels of government will complicate implementation, but by careful allocation of resources, state and local groups can innovatively combine regulation, acquisition, flood warning systems, and other measures to serve multipurpose community goals. The federal government should continue to point the way, support, and assist state and local governments to develop or to continue and strengthen the programs they have already initiated.

Major strategies should include:

- (1) All levels of government should implement a carefully tailored combination of floodplain management incentives and disincentives initiated in the 1970s to encourage individual responsibility in floodplain use. These include partially subsidized insurance, regulations, disaster assistance conditioned on mitigation measures, flood control measures constructed on a cost-share basis, and selective acquisition. Governments should remedy gaps and deficiencies in existing programs to make them effective and equitable. Floodplain regulations should be simplified, better quantified, and carefully coordinated with other techniques for land and water management. Local governments should upgrade interim regulations. The federal government should support the strengthening of state, local and private roles in floodplain management.
- (2) Increased specificity is needed in federal, state, and local mapping, standard-setting, and technical assistance to deal with special flood problems such as wave heights, combined erosion and flood hazards, high velocity flows, sheet flows, flash flooding, and long-term fluctuations in ground and surface water levels. Local conditions and the particular

needs of rural, urban, and metropolitan areas must also be addressed.

- (3) All levels of government should put greater emphasis on pre-disaster planning and postdisaster response for areas threatened by severe flooding. Coastal barrier islands and high velocity beach zones should have special consideration because flood and erosion threats are severe, development pressures are great, and maps are often inadequate. Greater emphasis should also be placed on inland areas subject to flash flooding.
- (4) Federal agencies (FEMA, SCS, the U.S. Geological Survey, the Corps, and the National Oceanic and Atmospheric Administration) should cooperate with states and localities to selectively upgrade 100-year flood definition criteria for areas with special problems to reflect wave heights, watershed urbanization, sediment (alluvial fans), high velocity flows and special characteristics. Upgraded maps should be at a scale and level of accuracy suitable for land use management.
- (5) The criteria used by states and localities to evaluate permits should reflect upgraded flood data and be expanded to serve multipurpose resource management goals. Staffs should be expanded and better trained to evaluate how a proposed activity will affect resource values and whether it is consistent with broad community goals. Procedures for determining 100-year flood elevations also need improvement, especially at the local level.
- (6) Federal, state, and local agencies should integrate floodplain regulations into wetland protection, coastal zone management, shoreland management, public works, and comprehensive land management programs through amendment of policies, plans and

regulations. Local agencies should coordinate floodplain management and stormwater management through comprehensive watershed management and combined or closely coordinated ordinances.

- (7) State legislatures should strengthen floodplain management by adopting or amending statutes, by enlarging staffs and by increasing management budgets. States should work more closely with local programs, particularly in rural areas to provide help in coordination of their programs, permit evaluation, mapping, monitoring, training, and education.
- (8) FEMA, the Corps, states, and local governments should tighten monitoring and enforcement of regulations. State monitoring with FEMA state assistance funds may be particularly effective.
- (9) FEMA, the Corps, SCS, states, and localities should stress innovative, multipurpose local floodplain management both before and after flood disasters. Floodplain management should be encouraged as an opportunity to meet multipurpose goals and correct past mistakes through a combination of techniques and approaches.
- (10) FEMA, states, and localities should conduct major training and education programs for floodplain decision makers such as landowners, engineers, architects, bankers and planners, on the nature and seriousness of floods and on ways to implement flood loss reduction measures such as elevation on fill or open works, floodproofing, flood warning systems, evacuation, relocation, and flood control works.
- (11) In cooperation with states and localities, NSF, FEMA, NOAA, the Corps, and other federal agencies should conduct research to systematically document flood losses by type, condition and

design of structures or uses, the causes of those losses, and the effectiveness of various flood reduction measures; to classify communities by type of flood problem; to further document effective management of special flood situations; and to improve the quality and cost effectiveness of flood studies.

- (12) OMB, FEMA, and Congress should reevaluate the framework of federal subsidies and incentives to ensure that they support the principle that "those occupying the floodplain should be responsible for the results of their actions." Continued efforts should be made to upgrade flood insurance rates to reflect actual risk. Cost-sharing requirements for state, local and private structural works should be enforced with larger nonfederal shares.

Frequent reference is made in this document to the National Flood Insurance Program (NFIP) and its administering agencies. Usually the Federal Emergency Management Agency (FEMA) is identified as the agency responsible for its administration. Occasionally, reference is made to the Federal Insurance Administration (FIA), which, as a part of the Department of Housing and Urban Development, had responsibility for administering the NFIP from its inception through the formation of FEMA in 1979.

CHAPTER I

THE 1970s: ACCOMPLISHMENTS AND PROBLEMS

A Decade of Continuing Flood Losses

The 1970s were a decade of major floods and more than \$25 billion in public and private flood losses in the United States. Almost 80% of the 1970s disaster losses were flood-related.¹ The average annual death toll from flash floods rose to about 200. This was more than double the rate of the 1960s and more than three times the rate of the 1940s.² It was also a decade of federal, state, and local cost-conscious efforts to reduce flood damages by guiding future uses away from flood-prone areas or requiring individual flood protection. Efforts were made to reduce flood losses to existing uses through relocation and floodproofing to break the cycle of damage, repair, damage, and further repair for damage-prone uses.

The decade was a period of reduced energy supplies and skyrocketing costs for aggregate, concrete, steel, and labor needed for construction of flood control structures such as dikes, dams and levees.³ It was a period of broadened environmental awareness and of tightened federal, state, and local budgets. It was a decade of experimentation and testing for various combinations of less expensive nonstructural means for reducing flood damages, with regulations playing a central role.

Major floods were a catalyst for flood loss reduction. The 1960s ended with the most intense hurricane in modern U.S. history--Hurricane Camille, which struck the Mississippi coast August 17-18, 1969, with up to a 24-foot storm surge and 230 mile-per-hour winds. It killed 255 people and left 68 missing. Destruction was widespread in Mississippi, Louisiana, Alabama, Virginia, and West Virginia.

Some major floods in the 1970s were:⁴

July 23-August 5, 1970. Hurricane Celia struck the Texas coast, causing 11 deaths and widespread damage.

June 9, 1972. A cloudburst in the mountains above Rapid City, South Dakota broke an earthen dam. Two hundred thirty-six were killed and 2,000 houses were damaged or destroyed. After the flood, Rapid City acquired much of its floodplain with \$45 million in federal funding. This event focused national attention upon flash flood problems and the vulnerability of dams.

June 14-23, 1972. Tropical Storm Agnes swept the Atlantic seaboard from Florida to New York with torrential rains and winds up to 70 miles per hour, causing 122 deaths and widespread property damage. Inland flooding was particularly severe in Maryland, Pennsylvania, and New Jersey. Over 300,000 structures were destroyed or damaged, with total property damage exceeding \$3.5 billion (\$5.8 billion in 1979 dollars).

In response to Agnes, Congress adopted the Flood Disaster Protection Act of 1973,⁵ which amended the National Flood Insurance Act of 1968. The 1973 act made flood insurance virtually mandatory as a condition for federal investment or disaster relief in the floodplain. New Jersey and Maryland adopted or amended floodplain regulatory statutes to broaden state programs. In addition, many thousands of communities enrolled in the National Flood Insurance Program (NFIP) and adopted regulations meeting minimum NFIP standards.

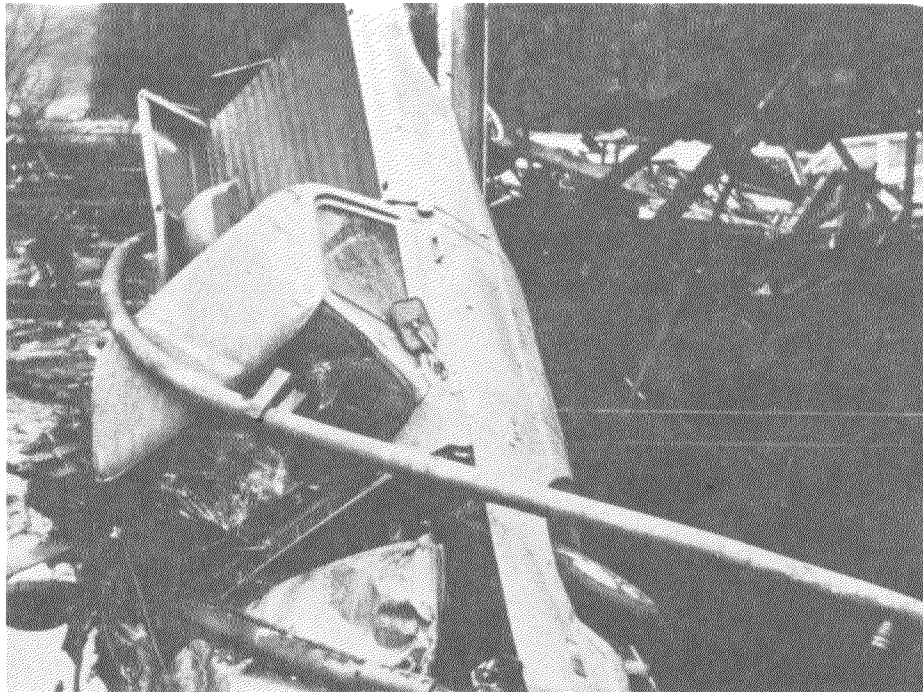
August 29, 1974. Hurricane Carmen struck the Louisiana coast with 90 mile-per-hour winds, causing damage to sugar cane crops, offshore oil installations, and the shrimping industry.

September 13-24, 1975. Hurricane Eloise hit the Florida and Alabama coasts with 100 mile-per-hour winds that severely damaged crops and structures and caused four deaths. Heavy rains over the Northeast also caused major flooding in eastern states, particularly Pennsylvania and Maryland.

July 31, 1976. Heavy rains at the headwaters of the Big Thompson River in Colorado sent a wall of water, in some instances 15 feet high, surging down the canyon, killing 136 and causing \$26 million in damages to public property and \$16 million to private property. U.S. Highway 34, which ran the length of the canyon, was essentially destroyed.

Larimer County adopted floodplain regulations for the area after the disaster, beginning with a six-month moratorium on rebuilding. Some of the damage-prone structures have been acquired at a cost of approximately \$3 million. This event gave impetus to the Floodplain Management Executive Order (11988) and to federal funding of an acquisition program within FEMA under Section 1362 of the Flood Insurance Act of 1968.⁶

February 6-7, 1978. The most severe winter flood of the decade occurred along the New England coast. A two-day "northeaster," with winds up to 90 miles per hour raised combined tides and storm surge elevations to 14 to 16 feet, and wave elevations up



Heavy rains caused the rupture of an earthen dam at Buffalo Creek, West Virginia, in September 1972. One hundred twenty-six people were killed in the disaster.

Photo source: Federal Emergency Management Agency



Severe damage in Scituate, Massachusetts, caused by the February 1978 "Northeaster."

Photo by Rutherford Platt.

to nine feet. Over 2,000 homes were destroyed with another 9,000 damaged and 29 lives lost in Massachusetts alone.

After the storm, Massachusetts adopted a building code requiring wave protection in coastal construction and reconstruction. The governor issued an executive order tightly controlling further state investment in the floodplain. The communities of Scituate and Hull strengthened their floodplain regulations to reflect wave heights. Rhode Island also strengthened its coastal floodplain restrictions to require an elevation of six feet above minimum NFIP standards for structures. To help states avoid future losses, FEMA funded the Section 1362 floodplain acquisition program.

April 1978. Rains caused water levels to rise along Lake Elsinore, California, severely flooding 600 properties. After this event local, state, and federal agencies developed new procedures for postdisaster planning, with relocation as one component.

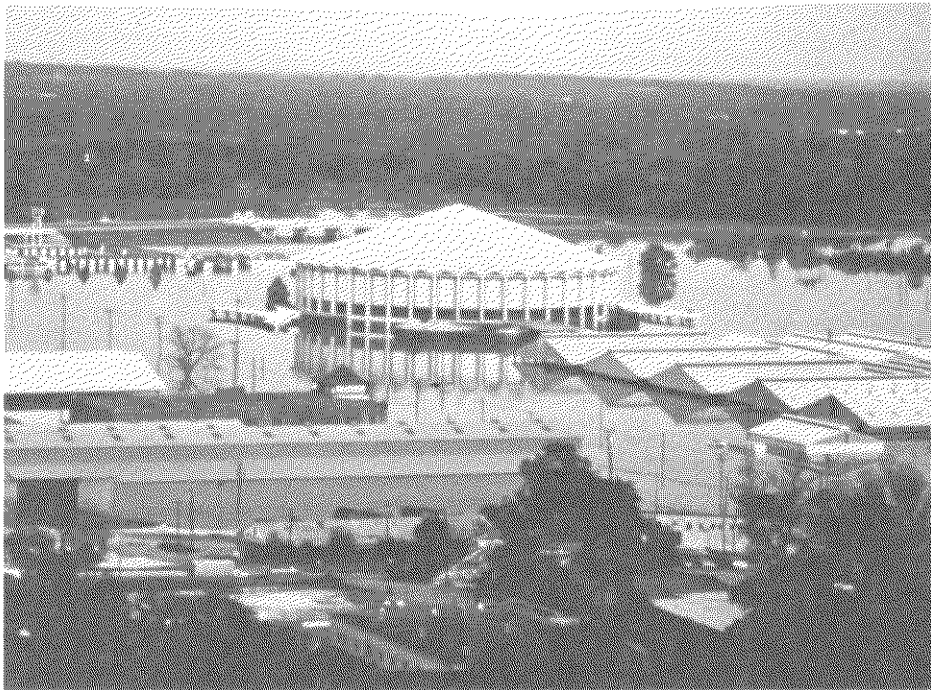
December 1978. Severe flooding in central Arizona killed 12 persons and destroyed 700 properties in Allenville, Hollywood, Duncan, and other towns. Arizona responded by adopting a relocation program that used federal and state funds to acquire and relocate an estimated 800 homes in 12 towns. The state also obtained federal funding for acquisition.

April 16, 1979. Heavy rain caused the Pearl River to top levees in Jackson, Mississippi, and severely inundate Jackson and other areas along the river. Over 1,900 residences, 298 businesses, and many public facilities were destroyed and/or damaged in Jackson alone. Total federal expenditures for the disaster were over \$375 million.

FEMA sent teams into the area after the disaster to assess flood hazard mitigation potential. Inadequate federal coordination during the disaster contributed to a July 1980 OMB directive requiring federal agencies to create postdisaster hazard mitigation teams under the leadership of FEMA and to improve postdisaster recovery procedures.⁷

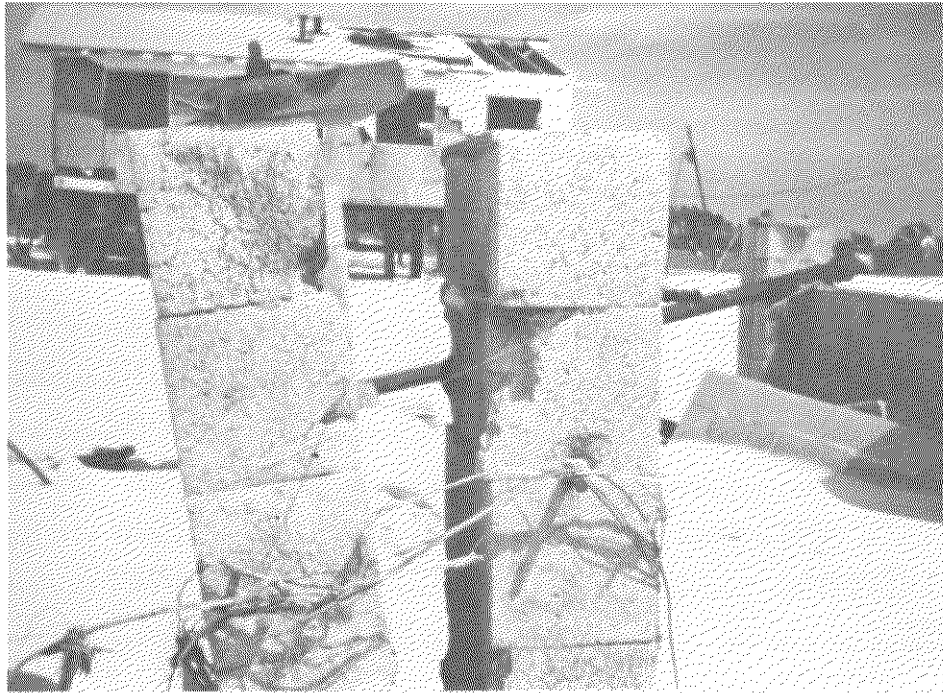
September 12, 1979. Hurricane Frederic struck the Alabama, Mississippi, and Florida coasts with storm tides of 10 to 12 feet and winds approaching 150 miles per hour. Estimated total damages exceeded \$2 billion. Over 1,500 structures were damaged or destroyed by flooding in the hardest hit areas, including Gulf Shores, Alabama (500 structures), Dauphin Island, Alabama (200 structures), and Fort Morgan, Alabama and vicinity (500 structures). Many damaged structures had been elevated to the 100-year flood elevation but without consideration of wave heights. Gulf Shores revised its regulations to reflect wave heights.

After this event, FEMA revised recommendations for coastal construction and focused attention on the severe erosion and flood threats to structures in rapidly developing barrier islands.



Flooding behind levees along the Pearl River in Jackson, Mississippi, caused \$500 million in damages.

Photo by Rutherford Platt.



Severe wave and water damage along the Alabama coast. Hurricane Frederic destroyed structures that had been raised enough to protect them from the 100-year storm surge but not from wave heights.

Photo source: Federal Emergency Management Agency

TABLE 1

DWELLINGS DESTROYED AND DAMAGED BY HURRICANES AND FLOODS (1969-1976)

Fiscal Year	Hurricanes	Floods
1969-70		
Destroyed	6,046	77
Damaged	48,734	32,080
1970-71		
Destroyed	1,059	43
Damaged	33,964	5,136
1971-72		
Destroyed	17	4,772
Damaged	24,218	127,802
1972-73		
Destroyed	---	2,181
Damaged	---	69,298
1973-74		
Destroyed	---	1,108
Damaged	---	28,969
1974-75		
Destroyed	14	407
Damaged	1,817	17,834
1975-76		
Destroyed	3,516	913
Damaged	27,497	20,423

Source: Data provided by the Federal Emergency Management Agency.

May 18, 1980. Mount St. Helens' eruption caused not only widespread destruction from the impact of the eruption and ash fall, but also severe flooding along the debris-clogged Cowlitz and Toutle Rivers. After the event, state and federal authorities shifted attention to broader-based disaster planning and response. Cowlitz County adopted strict regulations for these areas, including plans for relocating some properties.

The 1970s thus ended as they had begun--with a series of catastrophic events.

During the period from July 1, 1973, to June 30, 1979, outlays from the Presidential disaster fund amounted to \$1.6 billion.⁸ Total mean annual losses approached \$4 billion by the end of the decade.⁹

Progress and New Directions

Flood damages and loss of life during the 1970s prompted the piecemeal adoption of many flood loss reduction measures which, by the end of the decade, formed a surprisingly comprehensive and well integrated federal, state, and local floodplain management program for public and private uses in preflood and postflood situations. Nonstructural measures such as regulations, disaster assistance, flood insurance, and flood warning systems were combined with structural measures not only to reduce flood losses but also to promote urban renewal and provide recreation opportunities, preserve wildlife, and meet other goals.

Congressional and executive initiatives to reduce flood losses through nonstructural measures in the 1970s were largely based upon the recommendations of a 1965 Presidential Task Force on Federal Flood Control Policy which concluded¹⁰ that

Principles of national economic efficiency require...that the benefits of floodplain occupancy exceed all associated costs, not merely those borne by the individual or enterprise which so locates. Total associated, or full social, costs include--

Immediate expenses of development,

Damages to be endured by the occupant or the expense of protective measures undertaken to reduce the frequency and extent of flood damage,

Damages forced on others as a result of encroachment, and public costs involved in disaster relief and rehabilitation.

Flood plain occupation in which benefits do not exceed the estimated total costs, or which yields lower returns than other uses such as recreation and wildlife conservation, is undesirable, because it causes an eventual net loss to society. Any public policy which encourages submarginal development adds to those losses.

The task force further concluded that¹¹

Despite substantial [flood control] efforts, flood losses are mounting and uneconomic uses of the Nation's flood plains are inadvertently encouraged. The country is faced with a continuing sequence of losses, protection, and more losses. While flood protection of existing property should receive public support, supplemental measures should assure that future developments in the flood plains yield benefits in excess of their costs to the Nation. This would require a new set of initiatives by established Federal agencies with the aid of State agencies to stimulate and support sound planning at the local government and citizen level.

Specific Progress in the 1970s

Growth of the National Flood Insurance Program (NFIP) conditioned upon land use regulations. In 1970, 3,800 property owners had enrolled in the NFIP. Total policy coverage was \$1.5 billion. By January 1, 1980, the NFIP had grown to almost 2 million policies with \$100 billion in coverage.

The program was designed to serve two principal objectives: to provide to state and local government a federally subsidized insurance (up to 90%) for existing floodplain uses as an incentive for them to adopt regulations guiding new development away from the floodplain; and to provide a mechanism whereby floodplain occupants eventually would help pay for flood losses. Although the program was voluntary at its 1968 inception, in 1973¹² it became partially mandatory when Congress adopted the Flood Disaster Protection Act which required that communities enter the program or lose federal disaster assistance and other benefits for activities in the floodplain. From 1974 to 1977, about 13,000 communities joined the program, in part because of these requirements, but more importantly, because communities were becoming aware of the program's benefits. Communities had to state their intent to adopt land use regu-

TABLE 2

NATIONAL FLOOD INSURANCE PROGRAM PAID CLAIM DATA BY CALENDAR YEAR

Calendar Year	Policies	Average Insurance Per Policy	Number of Paid Claims	Total Losses	Claim Frequency (Per 100 Exposure Units)	Average Paid Claims Cost
1972	105,231	\$16,140	2,745	\$ 6,510,654	2.6	\$2,250
1973	232,677	17,060	15,485	12,694,833	6.7	2,548
1974	342,529	21,950	10,949	23,208,853	3.2	1,936
1975	495,585	25,440	19,982	34,968,535	4.0	3,588
1976	682,386	28,690	12,135	50,114,420	1.8	4,454
1977	996,553	30,100	13,477	74,761,406	1.4	5,678
1978	1,298,383	33,150	28,859	99,456,110	2.2	5,016
1979	1,518,210	37,650	69,175	117,069,208	4.6	6,458

Source: Data provided by the Federal Emergency Management Agency

lations as a condition to entering the program. Despite amendments in 1977¹³ which weakened the 1973 act by permitting federally insured banks to insure conventional loans in communities not participating in the program, few communities chose to withdraw.

Enhanced disaster assistance conditioned on postflood hazard mitigation. Prior to 1970, a variety of disaster assistance grants and loans were available to victims of federally declared disasters. The President was then (as now) authorized to declare disasters at the request of a state governor if the necessary assistance exceeded the resources of the state or local government. The Disaster Relief Act of 1970¹⁴ (adopted in response to the San Fernando earthquake) made five new types of disaster assistance available to private individuals, states, and local governments: free temporary housing for one year, disaster unemployment insurance, food stamps, grants to local governments with major loss of tax revenue, and forgiveness of up to \$2,500 in Small Business Administration (SBA) loans.

The Flood Disaster Protection Act of 1973,¹⁵ adopted after Tropical Storm Agnes, broadened assistance to forgive federal loans up to the first \$5,000 and lowered interest rates on additional balances to 1%. This money is available after a Presidentially declared disaster or after SBA and the Federal Housing Administration make their own disaster declarations in smaller disasters. Under the 1973 law, the federal government assumed costs previously assumed by the Red Cross for goods and services such as bulk cleaning supplies, temporary housing, and household accessories. It also introduced provisions for withholding federal benefits from flood-prone communities that chose not to participate in the NFIP.

The Disaster Relief Act of 1974¹⁶ (Section 406) made available disaster loans and grants to states and local governments on condition

that recipients evaluate and mitigate hazards. FEMA adopted hazard mitigation regulations to implement this act in 1979.¹⁷

Increased local regulation of flood hazard areas. Encouraged by the National Flood Insurance Program, strengthened state regulatory programs and environmental concerns, most communities with flood problems adopted at least preliminary regulations. In 1970, only about 300 to 400 communities had adopted floodplain regulations. By May 1981, over 17,000 had adopted or indicated an intent to adopt regulations in order to qualify for the NFIP.

Strengthened state floodplain management programs. In 1970, 24 states had adopted either direct state floodplain regulations or state standards for local regulations. By 1980, 31 states had adopted programs. Many states significantly strengthened and expanded existing programs during this period.

Accelerated floodplain mapping. In 1970, only a small portion of the nation had flood hazard maps. During the 1970s, the U.S. Geological Survey prepared "approximate" floodplain maps for 20,000 flood-prone communities. FEMA and its study contractors prepared more detailed maps for 3,500 communities. New FEMA maps for 6,500 communities are in various stages of completion. Maps for some areas were also prepared by the SCS, the Corps, and the Tennessee Valley Authority (TVA). California, Iowa, Maryland, Nebraska, New Jersey, and Wisconsin have prepared maps for some areas and many local communities prepared their own larger-scale maps to facilitate regulation.

Hazard mitigation requirements for public uses. In 1970, public uses were rarely protected from flooding, despite the 1966 Executive Order 11296, Evaluation of Flood Hazards. This order directed federal agencies to encourage "a broad and unified effort to prevent uneconomic use and development of the Nation's floodplains." In 1977, President



House threatened by erosion from flash flooding in Big Thompson Canyon, Larimer County, Colorado.

Photo by Rutherford Platt.

Carter issued Executive Order 11988, Floodplain Management, which strengthened and superseded E.O. 11296 by requiring federal agencies to avoid public investment in the floodplain, including grants in aid to local governments, if alternatives exist. In the 1970s, many states also amended state regulations or issued executive orders to control public uses of the floodplain.

Emphasis on nonstructural approaches. In the 1970s, all levels of government shifted attention to nonstructural measures to reduce flood losses, although some dikes, dams, levees and channelization projects continued to be built. Congress emphasized nonstructural approaches in the National Flood Insurance Act of 1968¹⁸ and its subsequent amendments as well as in the disaster assistance acts cited above. Congress enacted Section 73(a)¹⁹ of the Water Resources Development Act of 1974, which required agencies to consider nonstructural alternatives, including floodplain regulation, acquisition, and relocation, "with a view of formulating the most economically, socially, and environmentally acceptable means of reducing or preventing flood damages." Executive Order 11988, cited above, emphasized nonstructural measures as did the President's Water Policy Message of June 6, 1978, and Executive Order 12113, Independent Water Project Review. The latter directive required that whenever water resources projects or programs are considered, a non-structural plan must be evaluated as one alternative.

Concern with dam safety. A number of dam failures with catastrophic losses of life increased national and state concern about dam safety during the 1970s.²⁰ When a dam formed from coal mine waste gave way in Buffalo Creek, West Virginia, in 1972, 118 people were killed. Two hundred thirty-six died in Rapid City, South Dakota, when an earthen dam burst after a severe rainfall. In reaction to these failures, Congress adopted the 1972 National Dam Inspection Act,²¹ which authorized the Corps

of Engineers to inspect dams. Other dam failures added impetus to the national dam inspection program. These included the spectacular rupture of the Teton Dam on June 9, 1978, which killed 11, left 25,000 homeless, and totally or partially inundated a 300 square-mile area. Thirty-eight died in Toccoa, Georgia, in November 1977 when heavy rains ruptured an earthen dam. In addition to the federal dam inspection program, which now covers 9,000 large dams, 44 states require state permits for dams.

Community and state innovation. In the 1950s and 1960s, state and local authorities often applied regulations alone to accomplish floodplain management goals. During the 1970s, many states and hundreds of local communities adopted innovative combinations of different types of regulations and in some instances combinations of regulations and non-regulatory measures such as acquisition and flood warning systems. These innovative programs have tested new approaches and now serve as models.*

Growing expertise. During the 1950s and 1960s, few local governments, regional planning agencies, or private contractors had expertise in floodplain management. Many groups lacked expertise in mapping, map interpretation, drafting and administering regulations, backwater computations, acquisition, environmental impact analysis, wetland analysis, and other related topics. In the 1970s, expertise at all levels of government and in the private sector increased, although lack of expertise is still a common problem. City councils, architects, engineers, insurance agents, bankers and others sought information on flood hazards, floodproofing, and similar subjects in order to adopt wise regulations, design low risk structures, and reduce hazards to existing uses. States, federal

* See Appendix A, Strengthening State Floodplain Management, and Appendix B, Innovation in Local Floodplain Management, for descriptions of some of these programs.



The East Hampton chapter of the Nature Conservancy purchased over 600 acres of coastal wetlands, dunes, and floodplains in East Hampton, New York.

Photo by Jon Kusler.

agencies, regional planning agencies, and universities provided training through workshops, technical assistance, guidebooks, and consultations.

Growing public awareness. Public awareness of flood problems grew during the 1970s due in part to widespread press coverage of flood disasters; floodplain mapping by FEMA, other agencies, and states; flood insurance requirements; public notice and hearings accompanying the adoption of regulations; and public education programs at all levels of government. Despite a growing general level of awareness, many floodplain occupants underestimated floods which did occur such as those from Hurricane Frederic.

Enhanced role for the private sector. Before 1970 the private sector played a limited role in hazard mitigation. The federal government, states, or localities were expected to remedy flood problems or provide disaster assistance. During the 1970s, industries and private homeowners floodproofed existing structures in some areas and helped establish flood warning systems.²² Local conservation organizations promoted floodplain acquisition and regulation. National organizations such as the Nature Conservancy and the Audubon Society educated the public and acquired wetlands, floodplains, and barrier islands. Banks also indirectly enforced floodplain regulations by notifying potential mortgagees of regulations and by refusing mortgages for flood hazard areas unless flood insurance was purchased and minimum local and state standards were met.²³

Recognition that flood hazard reduction must be a cooperative effort. In the 1950s, flood problems were addressed primarily by the federal government through flood control works. In the 1960s, at least 24 states adopted regulations or standards for local regulations. Although local programs grew in the 1970s, the decade also confirmed that the partnership of all three levels of government is needed to effectively reduce

flood losses. This partnership is the basis for A Unified National Program for Flood Plain Management²⁴ adopted by the U.S. Water Resources Council and member agencies in 1976, revised and sent by President Carter to Congress in 1979. This partnership is reflected in the cooperative work of FEMA, the WRC and the Coastal Zone Management Program to strengthen state and local programs, and in requirements of OMB and Congress that states and local governments cost share in floodplain management.

Growing awareness of floodplains as natural resources. In the 1950s and early 1960s, concern about the value of floodplain land for recreation, farming, forestry, wildlife, and pollution control was limited. During the 1970s, widespread recognition of these resource values²⁵ led to: (1) the adoption of Executive Order 11990, Wetland Protection and Executive Order 11988, Floodplain Management; (2) the Federal 404 permit program providing protection for navigable waters and wetlands;²⁶ (3) state wetland statutes in most coastal and some inland states; (4) state shoreland zoning programs in seven states; and (5) thousands of local resource protection programs, including shoreland zoning, wetland regulation, agricultural land zoning, and mineral resource zoning. Coastal states became concerned about barrier island and beach protection and comprehensive coastal zone management. Where complete protection of resource values was not feasible, floodplain and resource protection regulations often required measures to reduce environmental impact as a condition of development permits.

Combining regulatory and nonregulatory measures. Prior to 1970, only a small number of communities had combined regulations with non-regulatory measures. Now perhaps 30% of flood-prone communities have combined regulations with acquisition, flood warning systems, evacuation plans, marking flood hazard areas, or flood control works.²⁷

Coordinated floodplain management. Until 1970, federal, state, and local flood control, floodplain regulation, disaster assistance, and open space programs were poorly coordinated and often contradictory. Real progress in coordination was made in the 1970s in large measure as a result of executive decisions such as issuance of the Floodplain Management and Wetland Protection Executive Orders, the creation of the Federal Emergency Management Agency, and adoption of a Unified National Program for Flood Plain Management. Congressional cross-referencing of disaster assistance,²⁸ flood insurance, and regulations also helped. Coordination at state and local levels was strengthened through state executive orders, improved state floodplain management programs, and more aggressive local programs.

Revisions in cost sharing. In the 1960s and early 1970s, the federal government subsidized federal flood control works and some types of disaster assistance at near-100% levels. Flood insurance received an overall 70% to 90% subsidy. During the 1970s, OMB, WRC, and Congress worked to develop consistent cost-sharing policies for flood control, disaster assistance, and other hazard reduction measures.²⁹ State and local cost-sharing increased from zero to 20%.

Improved review for structural projects. During the 1960s, WRC and its member agencies developed federal criteria ("principles and standards") to formulate and evaluate the economic costs and benefits of water resources projects.³⁰ During the 1970s, these criteria were refined and revised³¹ and Executive Order 12113 proposed an independent executive project review function for water resources projects. Federal environmental impact review procedures for projects were strengthened, and many states and localities adopted their own environmental impact review procedures.

Research. During the 1950s and 1960s, floodplain research focused on general policy issues; during the 1970s, it shifted to implementation. Many reports, manuals, and other materials addressed the flood insurance program, disaster preparedness, postdisaster response, floodplain regulations, flood warning systems, and floodplain acquisition.³² The effectiveness of state and local floodplain regulations was examined by several major studies.³³ More than a dozen manuals and reports dealt with floodproofing techniques.³⁴

Improved education and technical assistance efforts. Before 1970, federal agencies and states did little to educate elected officials, planners, architects, lawyers, and others in the specifics of floodplain management. During the 1970s, federal and state agencies distributed manuals, ordinances, and other materials and conducted hundreds of workshops with local governments. A variety of floodplain management films and slideshows were developed and more technical assistance was provided to local governments in map interpretation and case-by-case evaluation of floodplain permits. The Corps, NOAA, SCS, TVA, and USGS strengthened their assistance programs.

Emphasis on improved disaster preparedness and postdisaster hazard mitigation. Until 1970, the goal of most federal, state, and local disaster response efforts was rapid "return to normalcy," which usually meant reestablishment of the status quo. In the 1970s, federal agencies improved their disaster preparedness and postdisaster hazard mitigation to reduce flood damage potential after flood losses and to break the cycle of repeated flood losses. The Disaster Assistance Acts of 1973 and 1974, which made mitigation a condition of disaster assistance, were important first steps. Additional measures³⁵ included federal funding for state and local disaster preparedness and evacuation plans; postflood assessment (e.g., Scituate, Massachusetts; Jackson, Mississippi); evaluation

of postdisaster responses and recommendations for improved response; and the OMB directive requiring the formation of postdisaster teams under the leadership of FEMA to assess mitigation potential.³⁶

Improved stormwater management. Before 1970, community stormwater management programs emphasized design of underground systems to convey five-year to ten-year flows from subdivisions to downstream areas as quickly as possible. In the 1970s, many metropolitan areas and some smaller cities and counties adopted not only subdivision regulations but grading, fill, and drainage ordinances that also applied to broader watershed uses.³⁷ These ordinances were designed to maintain natural flood levels by restricting impermeable surfaces, regulating vegetation removal and requiring detention ponds and compensatory storage. Regulations also included above-ground drainage systems capable of conveying 50- to 100-year floods. Large-scale mapping and hydrologic investigations that include future watershed conditions and flood storage formed the technical basis for these measures.

Principal Federal, State, and Local Roles

Progress in floodplain management in the 1970s was due to joint federal, state, and local efforts which are discussed in greater detail in the following chapters. The federal role in nonstructural floodplain management was to provide incentives and guidance, including subsidized flood insurance; standard-setting for state and local activities as a condition to flood insurance; disaster assistance; and grants in aid for acquisition; mapping; technical assistance; public education; and research. The federal government also constructed flood control works and flood warning systems and selectively acquired floodplain areas and floodproofed structures. These activities formed an increasingly comprehensive program during the decade, even though they were often perceived as piecemeal or special problem responses.

The state role was also to set standards, map, provide technical assistance, and educate the public. Thirty-one states regulated or established standards for local floodplain regulations. However, most of the actual implementation was done by local units of government (cities, villages, towns, and counties).

Regional planning agencies were not generally authorized to adopt floodplain regulations or acquire floodplains. However, many agencies, such as the Southeastern Wisconsin Regional Planning Commission, assisted local governments to draft and administer ordinances, gather data, and plan for matters of regional concern.

Local special government divisions such as sewage and flood control districts played important floodplain management roles in some areas. Their roles will probably become more important, particularly for metropolitan areas where stormwater management is being integrated with floodplain management within each watershed.

Problems with Implementation

Despite progress in the 1970s in developing comprehensive federal, state, and local floodplain management, gaps remain and implementation is incomplete. In the following sections, problems with implementation will be described first by geographic location and then by type of program.

Coastal Areas

Floodplain management in the 1970s has been least effective along the coasts, which have the most severe hazards and the greatest development pressures.³⁸ Perhaps 70% of the damage-prone structures in the nation lie in coastal areas. Many are located below the 100-year flood elevation. Coastal hazard areas are of two types: (1) wave or "velocity" zones,³⁹ often extending 200 to 2,000 feet inland, which are subject to storm waves, inundation and sometimes erosion; and (2) backlying areas,



Typical beach, dune system, backlying salt marsh, and bay can be seen in this aerial view of a barrier island (Sapello Island, Georgia).

Photo source: Georgia Department of Natural Resources.



During a hurricane, public safety is threatened due to limited access to and from barrier islands such as Sanibel Island, above.

Photo source: John Clark

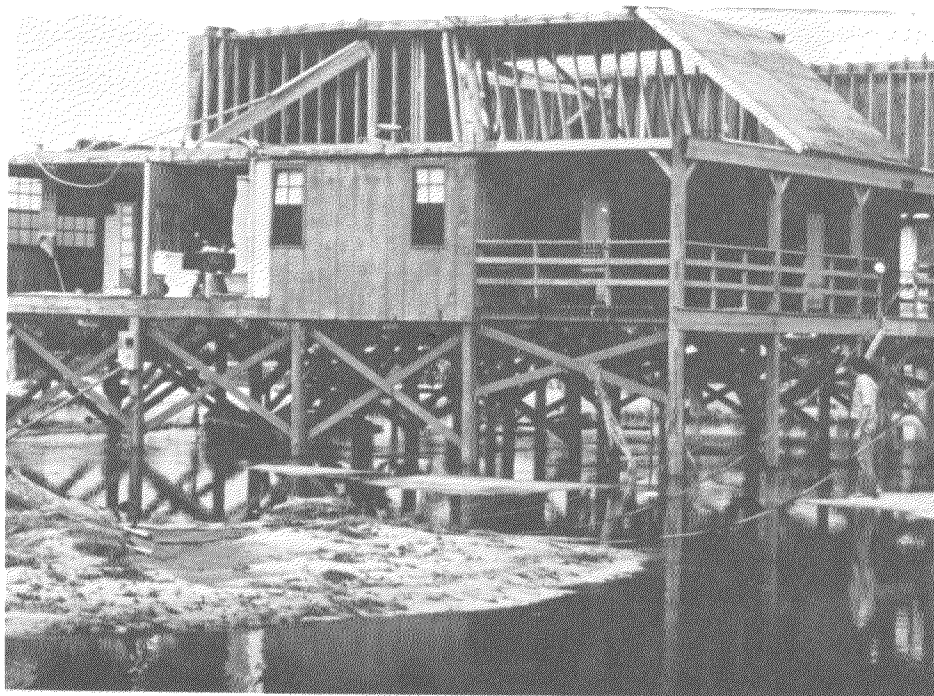
extending 2,000 feet to several miles inland, which are primarily affected by inundation.

Development in high velocity wave areas has been the major problem where the coastline is flat and waves may travel far inland. Beach front and barrier island areas with storm surge and wave elevations of 14 to 20 feet are found along much of the mid-Atlantic, Florida, and Gulf coasts. Velocity zones are less a problem along bluff shorelines of the West and upper New England, but erosion there is a significant threat.

Barrier island development is a special problem because of the combination of storm surge, waves, erosion and the inadequacy of evacuation routes to the mainland during hurricanes.⁴⁰ From the coast of Maine to Texas, there are 288 elongated, narrow "barrier" islands made up of unconsolidated and shifting sand.

Most of these islands are moving landward at rates of three or more feet each year.⁴¹ Winds, tides, waves, currents, and rising sea levels of six to 15 inches per century cause this movement. Barrier islands are the first landforms affected by hurricanes and northeasters striking the Atlantic and Gulf coasts. With average elevations of less than six feet, the waves and storm surges deeply inundate the islands and cause major erosion.

Until the twentieth century, development on barrier islands was largely confined to fishing shacks and seasonal structures in bayside areas. In the 1960s and 1970s, the demand for second homes led to massive construction of houses and condominiums. A Department of Interior report estimated that island urbanization proceeded at twice the mainland rate during the 1970s and that 14% of the barrier island area had been developed at urban densities,⁴² compared to 3% of the rest of the nation's



Hurricane wind and flood damage along the Alabama coast.

Photo source: Federal Emergency Management Agency



Flood and erosion-damaged road, St. Augustine, Florida.

Photo by Jon Kusler.

land. Federal investment in roads, sewers, water supply systems, and flood insurance has encouraged and helped finance this growth.⁴³

Despite the severity of flood hazards in wave action areas, flood-plain regulations have been only partly effective. FEMA flood maps did not reflect wave elevations and erosion. State regulations for such areas were virtually nonexistent until the mid-1970s, even though state regulation of inland flood hazard areas was widespread. Most of the 188 local governments with jurisdiction over barrier islands adopted minimum NFIP regulations, but the regulations did not cover wave heights or erosion. State programs lacking technical assistance capability limited the effectiveness of local programs. Flood insurance subsidies were also high in wave zones, which may have encouraged private development.

FEMA is now developing new maps and individual ratings for structures in velocity areas. However, it will be at least several years before revised maps are available for most of the coast.

Hurricane Frederic pointed up the seriousness of flood problems for coastal velocity zones and the inadequacy of existing maps and standards.⁴⁴ A modest-sized storm, Frederic seriously affected about 50 sparsely populated miles of the nation's 58,200 miles of coastline. A combination of storm surge, waves, wind, and erosion damaged or destroyed approximately 1,500 structures, with losses exceeding \$2 billion. Wind and waves destroyed 80% of the 500 structures in the first tier along a 20-mile barrier spit from Fort Morgan to Gulf Shores, Alabama. Many had been elevated to the 100-year flood protection level, but that elevation did not account for wave heights on top of the standing water. Consequently, many houses were swept off their pilings. Much of the dune system was also destroyed. Shoreline erosion averaged 45 feet inland along the Gulf side of the western two-thirds of Dauphin Island and 76 feet along the Mississippi sound side.⁴⁵ Erosion was particularly

severe where driveways, drainage channels, boat channels, and marina entrances acted as conduits for flood water. House supports (even where houses were built on pilings) increased turbulence and accelerated erosion.

Hurricanes of this sort are not freak events. On the average, two hurricanes strike the mainland United States each year, with the likelihood of one hitting Florida every 1.5 years.⁴⁶ One hundred twenty-nine hurricanes have struck the Atlantic and Gulf coasts since 1900. Fifty-three had winds of at least 110 miles per hour. The two deadliest killed 6,000 in Galveston in 1900 and 1,500 at Lake Okeechobee, Florida, in 1928. The fact that a major hurricane has not struck the Florida or Atlantic coast in the last 20 years has led to unwarranted optimism.

Although velocity zone damages are often the most serious, problems with coastal development are not confined to this zone. Backlying lands one-half to several miles inland along the mid- and south-Atlantic and Gulf coasts are often flooded three to eight feet by a 100-year storm. These areas are also subject to much greater wind velocities (75 to 150 miles per hour) and combined wind and water damage than are comparable riverine properties for a similar 100-year flood. Winds and the rapid rise and fall of hurricane-driven flood waters increase wave heights and water velocities, although backlying areas do not technically qualify as wave velocity zones. Regulations have been adopted for most coastal areas, but most do not protect against high velocity winds or waves.

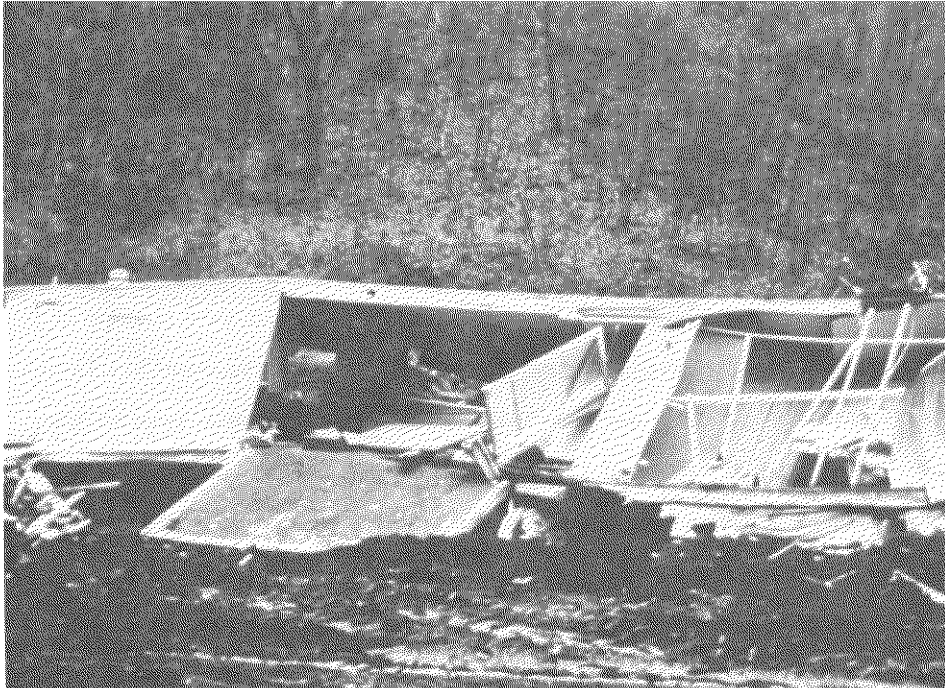
Inland Areas

Floodplain management in the 1970s was more successful in inland areas where the combined threat of wind, water and erosion was less serious. Development could be shifted to upland sites in many instances; the demand for waterfront sites was not as strong. Relatively permanent

adjustments such as elevation on fill were more successful than in coastal areas that are eroded by high velocity water. Many states adopted strong floodplain regulations. Moreover, many communities have adopted their own aggressive and innovative floodplain management programs. The concept of a "floodway" linked to the prevention of damage to upstream and downstream landowners had broad-based political and legal acceptability. Structural solutions and relocation also proved practical in many situations.

Despite the greater success of inland floodplain management efforts, problems with implementation also arose in some areas. Approximate flood maps that failed to provide the 100-year flood elevation and floodway boundaries were the only maps available for most rural and urbanizing areas where much of the new development occurred. Some local governments lacked sufficient expertise to administer regulations, particularly in rural areas. Only a portion of the country had state floodplain programs with strong technical assistance capability. Development in upstream areas often substantially increased flood heights in downstream areas, particularly in urbanizing watersheds.⁴⁷ The possibility of federally funded flood control measures discouraged communities from adopting stringent floodplain regulations.

Lack of specificity in measures for inland flooding was also a problem. NFIP standards and those of most states have been quite successful for low-velocity and moderate-duration flood areas located along major rivers and streams. The single-district and two-district ordinances developed for Volumes 1 and 2 of Regulation of Flood Hazard Areas, were designed for these areas. However, for inland areas with unique flood characteristics application of these standards and models has caused problems.



Mobile home destroyed by flooding at Buffalo Creek, West Virginia.

Photo source: The Federal Emergency Management Agency

Flash flooding and high velocity flows. High gradient streams with rapid flood flows and, in some instances, flash flood characteristics are found in all areas of the nation, but they are concentrated in the mountain states. The National Weather Service (NWS) has identified at least 2,500 communities with flash flood problems.⁴⁸ Particularly serious flash floods occurred in Rapid City in 1972 and Big Thompson Canyon in 1978. The two floods killed 372.

The regulations established by the NFIP and those proposed in Volumes 1 and 2 were partially unsatisfactory for such areas. Floodway modeling that assumes subcritical flows was not satisfactory for high velocity or supercritical flows. These areas needed much stricter regulations to deal with high velocities and flash flood conditions. Unfortunately, no manuals or ordinances have been developed for high velocity or flash flood conditions.

Long duration flooding along lakes and ponds. Long duration flooding occurs along major lakes with fluctuating water levels such as the Great Lakes and also around thousands of smaller lakes and ponds fed by groundwater. Regulations developed for riverine areas that permit elevated development in areas subject to short duration flooding have proved inadequate for these areas, since most structures on pilings will be damaged or rendered useless if surrounded by water for months or years. For example, once flood insurance became available, Lake Elsinore, a community along Lake Elsinore in California, amended its floodplain regulations to permit buildings elevated on pilings to the 100-year flood protection elevation, as permitted by the NFIP. Previously it had prohibited development on ground below the elevation of fluctuating lake levels. After basinwide rainfall caused long-duration flooding in 1979, elevated structures were isolated and rendered unusable. In many instances, the water and waves gradually destroyed them. Because of

this problem, the community again tightened its regulations and prohibited development except where the land surrounding the structures was above the 100-year flood elevation.

Flooding behind dikes and levees. Regulations have been difficult to enforce in areas that have levees and dams to protect from a 100-year flood. Landowners often believe they are protected, so they oppose regulation, unaware that inadequate drainage causes flood problems in such areas. When a flood exceeds design capacity, damage to backlying areas can be catastrophic. For example, \$500 million in damages occurred along the Pearl River in Jackson, Mississippi, when flooding overtopped levees, inundating backlying areas to the full heights of the flood.

Flooding along small streams and drainageways. Floodplain mapping and regulations in the 1970s focused on the floodplains of larger rivers and streams. However, substantial urban and metropolitan flood damages were caused by flooding along smaller creeks and streams. Urbanization also increases peak flows. Adequate watershed mapping and programs that combine floodplain regulation and stormwater management are rare.

Alluvial fans and mud flows. Flood mapping and regulation for riverine areas have been only partially applicable to areas built on alluvial fans or those subject to mud flows. In these regions, a traditional floodway concept does not apply and elevation requirements make little sense if the force of the flow will destroy pilings or the lower floors of structures. Alluvial fan flood problems occur in the canyon areas of the West and Southwest. Rather than following a well-defined course, flood waters exit the canyons through many small, rapidly shifting channels. Flash flooding is common, and flood damages are often compounded by severe erosion.

Mud flows are caused by unstable, supersaturated soils. The great force of the moving mass makes mud flows particularly damaging. The cost of cleanup is very high since mud must be mechanically removed.

FEMA and the Corps are trying to address alluvial fan and mud flow problems more specifically, but maps and regulatory standards tailored to these special needs are still needed.

Program Problems

Although problems with implementing state and local floodplain management in the 1970s have varied, most programs have the following difficulties.

Federal efforts focus on urban areas. Most NFIP floodplain mapping and technical assistance has focused on urban areas that have the most existing flood-prone uses and the greatest potential for flood insurance. The NFIP has paid much less attention to rural and urbanizing areas where the opportunity for guiding future uses is greatest.

Existing uses. The 1970s demonstrated that floodplain regulations are least effective in reducing losses to existing uses, unless the uses are destroyed or very seriously damaged by floods.⁴⁹ For developed areas, even after a severe flood, pressures for rebuilding are often so great that communities permit redevelopment without flood protection measures. Regulations have not effectively controlled repair of damaged buildings.

Untested floodproofing measures. The long-term adequacy of many structural floodproofing measures for commercial, industrial, and residential buildings is questionable.⁵⁰ Preliminary surveys after actual flooding show that total waterproofing from even low levels of inundation (2 to 3 feet) is difficult. Structural floodproofing is particularly vulnerable to large floods, waves, and high-velocity flows: few structures can withstand the force of a three-foot breaking wave. In

addition, temporary floodproofing measures such as emergency doors are likely to be placed incorrectly or become inoperative. Long-term losses are also likely when flood adjustments are used such as elevation on wooden pilings which may deteriorate over time.

Flood maps underestimate hazards. Flood maps often underestimate the elevation and severity of actual hazards.⁵¹ This problem is particularly serious in coastal areas where wave heights and combined erosion and flood hazards are not considered. At some points along the coast with steep offshore water depths and high waves, the 100-year elevation shown on FEMA maps may be reached annually or with a 5- to 10-year recurrence interval. Flood velocities, erosion, and duration of flooding are also inadequately considered in some inland areas. Because urbanization of watersheds greatly increases flood flows, flood maps become quickly obsolete.

Activities with severe flood damage potential are unregulated. Regulations that require elevated or floodproofed structures often do not apply to public works such as bridges, roads, sewer systems, and water supply systems that must be constructed to serve these areas. Increased and repetitive flood losses to these works result. Location of hospitals and low income housing in hazard areas threatens public safety.

Placement of hazardous items such as gasoline and propane tanks is also often inadequately regulated. These may cause fire and pollution during floods and injury to rescue workers. If inadequately anchored, they may also break free and lodge in bridge openings, obstructing the flow of flood water.

Mobile homes and mobile home parks are common in the floodplain and are subject to severe flood damages. Mobile homes often break free from their foundations and lodge in bridge openings or crash into other



Empty gas storage tanks, Austin, Minnesota. During floods, gasoline and propane tanks may float free, causing fire and pollution problems as well as increased flood damages.

Photo source: Patricia Bloomgren

structures. Many of the flood-related deaths at Rapid City, Buffalo Creek, and during Hurricane Agnes were due to occupancy of mobile homes in the floodplain. Inadequate regulation is common.

Legal and administrative inadequacy of emergency regulations.

Regulations adopted by many of the smaller towns and rural communities that remain in the emergency program of the NFIP are often inadequate both in substance and administration. Many communities have adopted only a "resolution" stating their intent to adopt detailed regulations when base flood information becomes available. Such resolutions require only that permits be secured for construction in the floodplain. In some jurisdictions the resolution has limited enforceability. Equally serious, administration of emergency program provisions is limited by lack of maps or case-by-case project evaluation procedures to identify 100-year flood elevations, floodways, and coastal velocity zones. The completion of an additional 4,000 floodplain studies in 1981-1982 and the conversion of these communities into the regular program will help to solve this problem. The NFIP's efforts to convert the remaining 6,000 communities into the regular program through "emergency conversion" procedures should also help, but only if the communities are required to adopt and monitor more effective regulations as a condition to the conversion. For example, the NFIP could require communities to make a case-by-case evaluation of flood hazard for all development permits.

Inadequate expertise in program development and administration.

Inadequate expertise in floodproofing techniques, map interpretation, flood warning systems and acquisition procedures continues to be a problem, despite gains in the 1970s. It is particularly serious in rural areas.

Floodplain maps not designed to meet land use management needs.

FEMA mapping is more responsive to insurance needs than to land use

management. Consequently, scales are often too small for management purposes, topographic information is lacking, and existing development and other useful information is omitted. Maps are rarely detailed or accurate enough to provide the basis for sophisticated floodplain management before and after disasters, although they have been relatively satisfactory for floodplains under light development pressures. More detailed flood studies and maps on a topographic or orthophoto base are needed.

Inadequate map data storage and dissemination. From a management perspective, raw map data and other data in flood insurance studies are often equally or more important than the map itself. Storage of raw data has been and continues to be unsatisfactory. FEMA study contractors (usually private engineering firms) are required to maintain the data for five years from contract completion. After this period, the data may be discarded. The unavailability of such data may seriously undermine the legal acceptability of regulations. In addition, updating will be very difficult, if not impossible. More satisfactory methods must be found to retrieve and store data for future use. The distribution and interpretation of maps has also been spotty and unsatisfactory in some instances.

Inconsistent administration of floodplain regulations. When development is proposed, many communities issue variances or amend regulations without compliance with minimum regulatory standards.⁵² Structures and fill may be permitted in floodways. First floors may be permitted at elevations far below the 100-year flood elevation. Sometimes failure to comply with standards is due to lack of flood data or expertise in evaluating permits. In other instances, federal, state, and local standards are ignored.

Inadequate coordination. Despite the executive orders and other measures of the 1970s, coordination is often poor for floodplain regulation, flood control, disaster assistance, flood insurance, park planning, capital improvement planning (roads, sewers), and other land and water management activities. Floodway delineation and watershed management policies of one community are often not coordinated with activities of upstream, downstream, or adjacent communities.⁵³ Floodplain regulations often fail to take into account resource protection and broader community land use planning activities.

Lack of specificity. In the 1970s, federal and state authorities applied relatively uniform standards for floodplain mapping, regulations, and technical assistance. These uniform, generalized approaches were necessary in light of available program budgets and to avoid charges of favoritism. Although this policy provided valuable minimum standards, the need to tailor program standards became apparent, especially for areas subject to waves, high velocity flows, flash floods, combined flooding and erosion, long-term fluctuations in water levels, or mud flows. Lack of specificity in program standards has also hindered attempts to deal with rural, urban, and metropolitan areas where density, existing uses, land use planning goals and levels of expertise differ.

Federal program bias for flood control works. Criteria for cost/benefit ratios of federal water resources projects permitted agencies to claim benefits for dams and other flood control measures to enhance undeveloped floodplain lands for structural uses, even though unflooded sites were available in the communities.⁵⁴ Nonstructural alternatives for maintaining an open floodplain are assigned minimal benefits in these calculations. This bias toward flood control is also reflected in large federal subsidies for flood control projects but minimal funding for floodplain acquisition, regulations, and flood warning systems.

Flood losses encouraged by subsidized insurance. The NFIP has provided the major incentive for state and local adoption of regulations and has been a positive influence in most situations. However, heavily subsidized insurance (60% to 90%) has also apparently encouraged some unwise floodplain and wetland development, particularly in coastal areas and on barrier islands.⁵⁵ This high subsidy lowers the risks to banks of making mortgage money available, and reduces the burden of losses for property owners. Subsidized insurance also acts as a disincentive to private floodproofing or relocation of existing structures. Low, subsidized flood insurance rates can be perceived by the public to imply a small chance of damage from floods.

FEMA is now addressing these problems by including wave elevations in coastal flood maps and accelerating the conversion of emergency program communities into the regular program. Flood insurance rates are being revised to reflect risk more accurately.

Inadequate monitoring of floodplain uses. Floodplain development has not been carefully monitored at federal and state levels. Each year FEMA carries out about 200 community field monitoring studies (CAPEs)^{*} to determine whether communities have adopted and are properly administering regulations.⁵⁶ These studies typically involve a site visit to a community, discussions with local government officials, and a tour of the floodplain. The visits do provide some measure of monitoring and deter blatant violations by other communities. However, FEMA has done little to monitor damages to individual structures after flooding and has completed only about 600 CAPEs for the 17,000 communities in the NFIP. CAPEs are not being carried out in all 10 FEMA regions. Rarely has FEMA suspended a noncompliant community from the flood insurance program. FEMA

* Community Assistance and Program Evaluation Reports.

lacks a staff sufficient to perform detailed followup on violations. Because of inadequate staff size and funds, state floodplain monitoring has also been generally unsatisfactory. In fiscal year 1981, state monitoring has been strengthened through the use of FEMA State Assistance funds.⁵⁷

Most monitoring of development is at the local level. Communities do not typically have formal monitoring systems to assess floodplain development on a regular basis, so they depend instead on complaints from citizens or random building inspections.

Addressing Problems

The remaining chapters of this report address these and other problems in greater depth including work done in the 1970s to address them and possible strategies for the 1980s to: reduce losses to future uses (Chapter II); reduce losses to existing uses (Chapter III); combine hazard mitigation and resource protection (Chapter IV); regulate uses at the state level (Chapter V); and regulate uses at the local level (Chapter VI). Judicial reaction to regulations is outlined in Chapter VII. The report concludes with a discussion of floodplain management strategies to reduce flood losses in the 1980s.

CHAPTER I

Footnotes

1. Statistics provided by the Federal Disaster Assistance Administration.
2. See National Oceanic and Atmospheric Administration (1978).
3. For example, the consumer price index lists the cost of cement at \$17.69 per short ton in 1970 and \$46.24 in 1979.
4. This information was derived in part from National Oceanic and Atmospheric Administration (1977).
5. Flood Disaster Protection Act of 1973, P.L. 93-234 (codified at 42 U.S.C.A. §§ 4001-4128 (West 1977)).
6. Section 1362, National Flood Insurance Act of 1968, P.L. 90-448 (codified at 42 U.S.C.A. §§ 4001-4128 (West 1977)).
7. Memorandum, Office of Management and Budget, July 10, 1980.
8. See Platt (1979).
9. *Id.*
10. Task Force on Federal Flood Control Policy (1966).
11. *Id.*
12. Flood Disaster Protection Act of 1973, P.L. 93-234 (codified at 42 U.S.C.A. §§ 4001-4128 (West 1977)).
13. Housing and Community Development Act of 1977 (P.L. 95-128).
14. Disaster Relief Act of 1970, 15 U.S.C.A. § 636 (West 1976).
15. Flood Disaster Protection Act of 1973, P.L. 92-234 (codified at 42 U.S.C.A. §§ 4001-4128 (West 1977)).
16. Flood Disaster Relief Act of 1974, P.L. 93-288, Section 406 (codified at 42 U.S.C.A. § 5131(c)(d) (West 1977)).
17. These regulations became effective on December 10, 1979, more than five years after the act was signed. 44 C.F.R. § 205.400-205.411 (1981). 44 C.F.R. § 9 (1981).
18. National Flood Insurance Act of 1968, P.L. 90-448 (codified at 42 U.S.C.A. §§ 4001-4128 (West 1977)).
19. Water Resources Development Act of 1974, P.L. 93-251 (codified at 33 U.S.C.A. § 701b-11, 701c (West Supp. 1981)). According to § 701c, cost-sharing provisions for nonstructural alternatives should be comparable to cost-sharing for structural alternatives with a maximum local share of 20%.
20. See Binder (1979).

21. Federal Dam Inspection and Safety Act of 1972, P.L. 92-367 (1972).
22. See discussion in Chapter III and Bresenhan (ed.) (1979).
23. 42 U.S.C.A. § 4012 (West 1977) requires, in effect, that lending institutions regulated by the federal government not make real estate loans unless flood insurance (if available) is purchased. The statute also directs agencies regulating banks, savings and loan associations and similar institutions to adopt regulations requiring institutions to notify a purchaser of property of special flood hazards or to obtain assurances that the seller or lessor has notified the purchaser.
24. U.S. Water Resources Council (1976). An updated version was sent to Congress in January, 1980.
25. See Chapter IV.
26. 33 U.S.C.A. §§ 401-466, 1251-1376 (West 1970).
27. See Chapters II and III.
28. See, for example, the Flood Disaster Protection Act of 1974, footnote 29, which requires flood insurance as a condition to disaster assistance.
29. Flood Disaster Protection Act of 1974, P.L. 93-251 (codified at 33 U.S.C.A. § 701b-11 (West Supp. 1982)).
30. The President's Water Resources Council, Procedures for Evaluation of National Economic Development Benefits and Costs in Water Resources Planning. 18 C.F.R. § 713 (1981).
31. 18 C.F.R. § 711 (1981) (Principles and Standards for Water and Related Land Resources Planning).
32. See publications listed in the bibliography of this report.
33. *Id.*
34. See the bibliography for a partial listing.
35. See footnote 8. See also Abeles, Schwartz, Haeckle & Silverblatt, Inc. and Ralph M. Field Associates, Inc. (1981).
36. Office of Management and Budget Memorandum, July 10, 1980.
37. See Chapter II for discussion of Baltimore County, Maryland; Alexandria, Virginia; Howard County, Maryland, and several other programs.
38. For studies concerning floodplain management in coastal areas see White *et al.* (1976) and National Oceanic and Atmospheric Administration (1980).
39. Velocity zones or coastal high hazard areas are defined by regulations (24 C.F.R. § 1909.1 (1981)) to include:

the area subject to high velocity waters, including but not limited to hurricane wash or tsunamis. The area is designated on a FIRM as Zone VI-30.

40. See references on barrier islands in the bibliography of this report.
41. See Kaufman and Pilkey (1979), Leatherman (1979), and Leatherman (1981).
42. U.S. Department of the Interior (1979).
43. *Id.* See also Sheaffer and Roland, Inc. (1981). This report concluded that (using an average purchase price of \$5,000 per acre) recent estimates indicate that acquisition costs could be one-fifth or less of the costs to the federal government of continuing its current development program on the undeveloped barrier islands. See also footnote 55.
44. An analysis of damages caused by Hurricane Frederic by Sheaffer and Roland, Inc. (1980) revealed that 322 houses out of a total of 442 in the first tier along 22 miles of coast from Fort Morgan through Gulf Shores, Alabama, were destroyed. One hundred seventeen out of 130 were destroyed in a 16-mile portion of the 22 miles. Of the 1,059 structures in the first three tiers along the 22 miles, 534 were destroyed--over 50%. First tier houses were generally 200-300 feet from the shoreline; second or third tier setbacks were generally 800-1,000 feet from the shoreline. Wave elevations at the shorefront were approximately 18 feet while the still water storm surge elevation was 11 feet.
45. See Penland *et al.* (1980).
46. See National Oceanic and Atmospheric Administration (1977).
47. See National Science Foundation (1980), which concluded that, "[u]rbanization increases peak flow rates from two to six times for the more frequent floods on small streams with less relative effects on larger events and larger streams." It recommended that "[p]lanning for urban storm run-off involving prediction of future probabilities of flooding should include consideration of future changes in land use." (p. 213)
48. See National Oceanic and Atmospheric Administration (1978). This total may (it is not clear from the report) include coastal communities.
49. See Chapter II.
50. *Id.*
51. See discussion accompanying footnote 5 in Chapter VIII.
52. This conclusion is based upon discussions with state floodplain management personnel (See Appendix A), FEMA staff, and examination of approximately 600 FEMA field reports (CAPEs) evaluating individual local programs. Although variances are routinely granted in some communities, many other communities are apparently "holding the line" in administration of regulations.

53. See Platt *et al.* (1980).
54. See Sheaffer and Roland, Inc. (1981). In analyzing criteria or federal water projects this report concluded that,

With regard to existing development, the economic evaluation of nonstructural measures such as flood proofing, rehabilitation, and evacuation can compete with structural measures on a reasonably equal footing. For new development, however, the deck is stacked in favor of structural measures. Unless the policies and evaluation procedures are changed to provide the proper consideration of alternative locations for new development, there is not much hope for greater success in the implementation of nonstructural measures....

There are always practicable alternative locations for new development, but potential for elimination of flood risks on the floodplain often causes floodplain owners to expect large economic gains through use of their lands for high-intensity development. Thus organized, they present a powerful economic and political force, usually successful, in opposition to any significant nonstructural uses of the floodplain (p. 8).

55. Whether federally subsidized flood insurance has encouraged floodplain development has been widely disputed. There has been little field study concerning development in insured and uninsured areas. In addition, it is difficult to separate the importance of insurance, regulation, recession, and other factors in encouraging or discouraging development in a particular circumstance. Nevertheless, most state and local officials interviewed by the author were of the belief that the insurance had encouraged some development although how much was unclear. Researchers who had addressed the topic generally showed this belief. Miller (1977) concluded after conducting a field survey of 15 communities, that once flood insurance became available, lending institutions in Westerly, Charlestown and South Kingston, Rhode Island and Galveston, Texas (1/3 of the communities studied) reversed earlier restrictions on mortgages in coastal high hazard areas.

Burby and French (1981) concluded, based upon a survey of 1,203 local jurisdictions (see description of this survey in Chapter V) that:

It often appears that the NFIP induces increased flood plain development because the same factors which lead communities to participate in the NFIP are also associated with continuing floodplain invasion. These factors include past invasion of the floodplain and a need for insurance and the potential for new construction in the hazard area because of its attractiveness for development. (p. 294)

State and local officials interviewed by the author suggested a stronger correlation. They argued that bank financing would not have been available for much of the new development without flood insurance. During the last five years, interest rates have been high, money has been scarce in most areas, and banks have carefully screened mortgagees. Due to the widespread availability of flood maps, bankers have been well aware of hazards (unlike the 1950's and 1960's). Would banks have provided mortgages with knowledge of such hazards, a tight money situation, and lack of meaningful private flood insurance? Probably not. Of course, other factors may also have contributed to floodplain development ranging from income tax write-offs for interest, favoring purchase of second homes in barrier islands and other high amenity areas by high income city-dwellers to federal subsidies for roads, water supply systems and the like.

The General Accounting Office is presently studying the effect of the National Flood Insurance Program in coastal development.

56. Regional Offices of the Federal Emergency Management Agency have prepared an estimated 600 Community Assistance Program Evaluation reports (CAPEs) to serve two principal and often complementary purposes: (1) monitor enforcement, and (2) provide technical assistance to communities. These reports include a field visit to the community, discussion with community officials (and in some instances banks and insurance agents) examination of files and field inspection of the floodplain. Monitoring efforts have been focused on areas where there have been complaints of noncompliance with federal regulations or severe flood problems and continued developed (e.g., Monroe County, Florida--the Florida Key; Ocean City, Maryland). Technical assistance efforts have focused on past disaster communities, (e.g., Scituate, Massachusetts) and communities requesting or needing assistance. Regionally, CAPE preparation has been uneven with most CAPE preparation in the mid-Atlantic states and the Midwest. Only a small number of CAPEs have been prepared for New England, the West and the South.
57. In 1981 and 1982 a number of states conducted systematic community monitoring efforts with help from FEMA state assistance funds. These include efforts by New Jersey to conduct CAPEs for all 270 New Jersey municipalities in the National Flood Insurance Program and efforts by California to monitor all regular program communities.

CHAPTER II

ADJUSTING FUTURE USES

Overview

Floodplain regulatory programs in the 1970s were designed primarily to guide the future use of undeveloped floodplains in order to reduce flood losses. Other goals included protection of natural resources, protection of the tax base, and implementation of federal, state, and local comprehensive land and water management plans. The overall objective was "wise" or socially beneficial use of floodplains in light of their values and special hazards.¹

Regulations in the 1970s were most effective in establishing minimum flood protection elevations and guiding development away from rural floodplains where land values were low and where alternative building sites were available. In urban and urbanizing areas, they also effectively protected floodways, dunes, wetlands, and other critical areas. They guided "infilling" of partially developed areas and redevelopment. By guiding future development, regulations reduced future flood losses.²

Regulations to guide future uses differed from state to state and community to community. Nevertheless, they were remarkably similar in one respect--almost all required protection of new structures to the 100-year flood elevation where flood studies or maps that included this elevation were available. All state floodplain regulatory programs adopted the 100-year standard for mapping and regulation during the 1970s. The National Flood Insurance Program and the Floodplain Management Executive Order adopted the 100-year standard. Most federal maps applied the standard.

Two approaches were applied at state and local levels to require protection of structures to the 100-year flood elevation. The most common

required elevation of residential structures on fill, pilings, or other open works and (alternatively) elevation or floodproofing of commercial and industrial buildings. The second prohibited new structures or reconstruction in the 100-year floodplain.

The first approach, taken by the NFIP and most state and local programs, allowed for a balance of flood loss reduction and development needs in areas with broad floodplains. It was most widely applied in Atlantic and Gulf coastal areas and along major rivers and streams. Regulatory standards prohibited fill and structures in floodway, wave velocity, and dune and mangrove areas where these activities would increase the 100-year flood elevation or flood velocities on other lands. Storm drainage measures were also commonly required.

Despite its advantages, this approach rarely led to substantial reduction of floodplain development.³ Problems, which are discussed below, also arose in defining 100-year flood elevations and in requiring adequate floodproofing of buildings. Moreover, the roads, sewers, and water supply systems that had to be extended to serve new flood fringe development increased total public flood losses. To be effective, implementation of this approach required detailed flood maps and technical expertise to evaluate floodproofing measures, flood heights, velocities, and other matters.

Hundreds of communities applied the second approach--one that prohibited all new development in the floodplain. This was most commonly used in areas with steep topography and narrow floodplains and in rural areas with low land values. The purpose was to prevent gradual increases in flood heights and velocities caused by the elimination of flood storage and encroachment in floodway areas and to reduce flood losses to costly public works such as roads, sewers, and water supply systems. It provides a measure of safety against uncertainties about the long-term effective-

ness of floodproofing measures. It protects resources and supports broader community land management objectives. Moreover, it can be applied with relatively imprecise flood data and low levels of expertise. However, it more often encountered political problems.

A combination of the two approaches was applied by thousands of local governments and many states. They prohibited all fill and structures in floodways and coastal areas, but permitted some fill and structures protected to the 100-year flood elevation in fringe areas. The restrictiveness of this approach depended on the definition of floodway, as discussed below.

Although the 100-year flood protection elevation requirement was used by much of the nation, the specifics of community regulations differed based upon community preferences, state standards and available flood data. NFIP requirements for state and local regulations varied according to the type and amount of information provided in its flood maps. Communities were required to upgrade regulations within six months of receiving upgraded flood data from the NFIP.

Problems in Implementation

Regulations were least effective in the 10,800 communities (as of January 1981) in the emergency program of the National Flood Insurance Program. Many of these communities have adopted only a resolution indicating their intent to adopt more detailed regulations in the future or a preliminary ordinance requiring building permits and general subdivision review. The legal sufficiency of the resolutions to control new development is questionable in some jurisdictions.⁴ In addition, most emergency program communities lack adequate maps and staffs.

Regulations were more effective at the state level and in the 6,300 larger communities enrolled in the regular program of the NFIP. Three to four thousand more are expected to enter the regular program in 1981-1983.

TABLE 3

TECHNIQUES TO REDUCE LOSSES TO FUTURE DEVELOPMENT

Adoption of floodplain regulations to guide new development away from floodplains or floodways or require elevation or floodproofing of structures

- Zoning
- Subdivision controls
- Building codes
- Special codes

Planning of public facilities, roads, sewers, and water supply systems to avoid floodplains, to provide for elevation of facilities, etc.

Floodproofing of new structures

- Elevation on fill or open works
- Temporary or permanent waterproofing
- Wet floodproofing
- Structural design elements
- Water resistant materials

Emergency evacuation

- Flood forecasting
- Flood warning
- Evacuation procedures

Acquisition of undeveloped hazard areas

- Fee (purchase, donation, exchange)
- Easements
- Transfer of development rights

Education

- Floodplain mapping
- Flood warning signs
- Workshops
- Distribution of pamphlets, newspaper articles, etc.

Preventing increases in stormwater runoff

- On-site storage requirements
- Regulations protecting flood storage areas

Resource protection and management regulations with hazard mitigation standards

- Wetland
- Dune
- Coastal setbacks
- Agricultural and forestry zoning
- Performance zoning

TABLE 3 (continued)

Tax incentives

- Preferential assessment of real estate in hazard areas pursuant to open space tax statutes
- Income tax incentives for bargain sales, donation of lands to public agencies, non-profit corporations
- Estate and gift tax incentives for donation of lands to public agencies, non-profit corporations

Flood control measures

- Dams
- Dikes, levees, seawalls
- Channel modifications

A community must enter the regular program within six months after FEMA completes a flood insurance study, which includes a map showing 100-year flood elevations, or the community's participation in the program will be suspended. A community qualifies for additional flood insurance upon entry into the regular program. It also must upgrade its regulations.

States and communities in both phases of the program encountered the following problems in reducing flood losses to future uses:

- NFIP and community criteria for defining the 100-year flood protection elevation sometimes underestimated hazards by failing to recognize wave and erosion hazards, changing watershed conditions, and other related factors.
- Flood maps defining 100-year floodplain boundaries and the 100-year flood elevation were available for only a portion of the nation.
- NFIP criteria for defining floodways (i.e., one foot of backwater effect) increased flood damages.
- NFIP criteria for defining coastal high hazard areas were inadequate in some instances. Few coastal high hazard zones have been mapped.
- Regulations failed to provide adequate protection for dunes and wetlands.
- Few floodplain mapping and regulatory standards were adequate to meet the combined needs of flooding and stormwater management in urbanizing areas.
- Methods for protecting structures to the 100-year elevation were subject to limitations.
- Federal subsidies for some flood control works and flood insurance undermined nonstructural floodplain management.

These problems and ways states and communities addressed them are discussed more fully below.

Inadequacies of the 100-Year Flood Protection Elevation

Most states and communities adopted the minimum NFIP standards for protection of structures in flood fringe areas. The NFIP requires that new structures in coastal and inland fringe areas either be elevated on pilings or fill or be floodproofed to the 100-year flood protection ele-

vation. Residential uses are to be elevated on pilings or fill.⁵ Commercial and industrial uses can be either elevated or floodproofed.

During the late 1960s, the NFIP selected the 100-year flood as the basis for regulation because it was considered a "middle-of-the-road" approach to balance potential damage against the costs of protection. NFIP studies during the 1970s showed that elevation to the 100-year flood level was, in general, cost-effective for landowners.⁶ Despite some controversy, states and localities also accepted the 100-year elevation as a general standard, but permitted some structures such as those for agricultural storage at lower elevations and required higher elevations for particularly sensitive or dangerous "critical uses" such as hospitals or nuclear power facilities.

Two problems were encountered in applying the 100-year standard: lack of agreement on criteria for establishing the 100-year elevation and lack of agreement on the most appropriate flood protection measures based upon this standard.

The first problem concerned assumptions in calculating the 100-year elevation. The NFIP decided to use existing watershed conditions to calculate the 100-year elevation because future watershed conditions are difficult to predict and FEMA had concluded that flood insurance rates must be calculated according to existing, not future hazards. One hundred-year surge elevations were calculated for coastal areas without consideration of wave heights because at first the method of determining wave heights was technically questionable and because strong political pressures opposed using such heights since they may add 50% or more to the 100-year flood elevation. These criteria and guidelines were challenged by some states and localities.

Basing flood protection measures on particular 100-year flood elevation criteria was also challenged. One study pointed out that per-

haps 60% of the flood damages in the 1970s resulted from floods exceeding 100-year levels as defined by NFIP criteria.⁷ If the capacity of a levee designed to the 100-year criteria is exceeded, backing structures are flooded to the full height of the 100-year flood.⁸

After severe floods in the 1970s demonstrated these deficiencies in applying a 100-year flood elevation criteria, some states and communities adopted more stringent protection elevations.

Regulations for urbanizing watersheds. Because FEMA flood maps assume existing watershed conditions in calculating flood flows in urbanizing watersheds, they can quickly become outdated. Urbanization may increase peak flow two to six times.⁹ To avoid this problem, a number of urban and metropolitan communities prepared their own maps based on assumptions of future urbanized watershed conditions.

- Arvada, Colorado, and other communities in the Denver area adopted floodplain regulations for the 100-year floodplain as defined through studies of the Denver Urban Drainage and Flood Control District which accounted for projected watershed development.
- Dallas, Texas, calculated runoff according to projected land use in the watershed.
- Tulsa, Oklahoma, has assumed future watershed conditions in its mapping and regulations since 1975.
- Racine County and other counties in the Southeastern Wisconsin Regional Planning Commission adopted regulations based on Commission studies that assumed future watershed conditions.

Regulations for broader inland floodplain areas. Most state regulatory programs and several thousand local programs have added "freeboard" (additional elevation) requirements to the NFIP 100-year flood elevation or have regulated based on the height of floods larger than the 100-year flood. This has been done in order to deal with increasing flood levels from urbanizing watersheds, special problems such as ice jams, or destruction of flood storage areas. For example, Wisconsin requires two feet of freeboard in all of its communities. Highland Park, Illinois,

requires two and one-half feet of freeboard, while Sioux Falls, South Dakota, and Howard County, Maryland, require two feet.

Regulations for coastal velocity zones and erosion areas. Some communities and states have gone beyond NFIP standards to reflect more accurately coastal wave and erosion problems.

- Massachusetts took into account wave heights when the state amended its building code regulations after the severe winter storm of 1979.
- Following the devastating hurricane in 1954, the governor of Rhode Island appointed a hurricane damage reduction task force, which formulated recommendations for two-zone regulations of coastal hazard areas. These were implemented by East Providence, Rhode Island, which prohibited structures in a high hazard zone severely damaged by the 1954 hurricane and required that structures in backlying low hazard zones be protected to a height of 15 feet, in contrast to a 100-year storm surge elevation of about 10 feet. South Kingston, Rhode Island, adopted a similar ordinance in 1975.
- Southampton, New York, requires a minimum elevation of 15 feet for new structures. The 100-year storm surge elevation is 10 to 12 feet.

Other communities with regulations reflecting anticipated wave heights and/or erosion hazards are Gulf Shores, Alabama, with a protection elevation of 15 feet; Santa Rosa Island, Florida, with a protection elevation of 13 feet; and a portion of Virginia Beach, Virginia, with protection elevations of 18.5 feet.

In remapping coastal areas, the NFIP now includes wave heights, but it will be several years before the maps are completed. FEMA is also considering individual insurance rating of structures in velocity zones to take into account wave heights.

Lack of 100-Year Flood Boundary Maps

As discussed in Chapter I, the USGS prepared "approximate" flood maps for 20,000 communities in the early 1970s. These maps were based on historical flood maps, records of flooding, and other sources of information. They varied greatly in accuracy, depending on available

information. These approximate maps have been of some value for regulatory purposes, but their use has been limited because they lack floodway and coastal high hazard area boundaries and 100-year flood elevations. FEMA did not require communities with approximate maps (about 11,000 of 17,000 in the NFIP) to undertake more detailed flood analyses to determine how proposed development would affect flood heights and velocities. Consequently, some development occurred in the 1970s (and is now occurring) in floodway and wave velocity areas and at elevations below that of the 100-year flood. Some of this development was encouraged by subsidized flood insurance, which is still available for new development.¹⁰

Some states and communities have taken steps to regulate new uses more effectively where only approximate flood maps are available.

- Some communities have prohibited development on an interim or long-term basis until detailed data becomes available for the entire approximate floodplain to avoid possible encroachments into high hazard areas and construction at inadequate elevations.
- Minnesota, Wisconsin, Maryland and other states have required permit review at the state level for development in approximate flood hazard areas in order to calculate 100-year flood elevations on a case-by-case basis and to study how the proposed development will affect flood flows. The states provide the results of this review to local governments and landowners.
- Maryland and Michigan require developers to undertake detailed flood studies consistent with state criteria to calculate 100-year flood elevations and whether new development will affect flood flows.
- California, New Jersey, Wisconsin, Arizona, several other states and many local governments undertook independent mapping with the help of consultants, regional planning agencies, or special districts. Some local governments produced flood maps exceeding minimum NFIP standards in accuracy and scale. FEMA later remapped these areas without use of the locally produced maps.

Problems with the Regulatory Floodway and the Lack of Floodway Maps

During the 1970s, many regulations applied the concept of the hydraulic conveyance regulatory floodway (i.e., the stream channel and a portion of the adjacent floodplain needed to convey flood flows from upstream to downstream points without increasing flood heights more than a predetermined amount). FEMA regulations require that riverine communities with a flood insurance rate map but without a floodway map prevent new construction, substantial improvements, or other development in the 100-year floodplain "unless it is demonstrated that the cumulative effect of the proposed development, when combined with all other existing and anticipated development, will not increase the water surface elevation of the base flood more than one foot at any point within the community."¹¹ Where floodway maps are available, communities must "adopt a regulatory floodway based on the principle that the area chosen for the regulatory floodway must be designed to carry the water surface elevation of that flood with no more than a one foot rise in surface water elevation at any point."¹² The community must also prohibit encroachments and construction within the regulatory floodway "that would result in any further increase in flood levels within the community during the occurrence of the base flood discharge."¹³ Similar standards have been adopted by many communities and states.

Problems have arisen in understanding and accepting these standards. The standards assume that some continued floodplain development will be permitted even if increased flood heights and velocities and increased flood damages result. The NFIP floodway based on one foot of allowable increase in flood heights also widens the floodplain. The increase of one foot in surface water elevation and resulting increase in water velocity may make the difference between flooding that can be controlled through emergency levees and flooding that cannot. The feasibility of

floodproofing structures is also affected because floodproofing higher than two feet for residences or three feet for commercial buildings is usually impractical due to water pressure on the floors and walls.

Because of these problems, at least a dozen states and many communities have adopted a more restrictive floodway standard. Water surface elevations may be raised no more than one-half foot (depending on the state and community). The "no-rise" floodway, which prohibits all future development which would increase flood heights measurably, is becoming more common. For example, Dallas, Texas and Rockville, Maryland, have adopted "no-rise" floodway regulations which apply to the entire 100-year floodplain. More restrictive approaches like these have been endorsed by the National Science Foundation.¹⁴

The FEMA floodway concept is difficult to apply in mountainous areas where steep topography and stream gradients cause high velocity flows throughout the floodplain. Water several inches deep can cause severe damage when it flows at five or more feet per second. Mathematical models for computing floodways are difficult or impossible to apply in high velocity flow areas. Consequently, some communities prohibit development throughout the entire high velocity floodplain rather than attempt to define a specific floodway.

Floodway mapping has been costly and time consuming. Maps are available for only 3,500 of the 20,000 communities with flood problems. Without such a data base, the flood conveyance function of floodways has little protection except in states or communities that prohibit all development in the floodplain or provide case-by-case analyses of the potential effects of development on conveyance or individually determine floodway boundaries.

Some communities use other means to define floodways if NFIP floodway maps are not available. Brown County, Wisconsin; Prince George's

County, Maryland; and Lewisburg Borough, Pennsylvania, have defined the floodway to be the 50-year floodplain. Other communities have established stream setback lines of 50 to 200 feet. Still others have applied an approximate "no-rise" or "natural" floodway concept which assumes no permissible increase in flood heights and can often be mapped more easily than a one-foot NFIP floodway.

With a traditional floodway permitting a one-foot rise, each floodplain must be hydrologically modeled to determine how much area is needed to convey specific flows with a one-foot rise. Detailed topographic information, flood flows, and estimates of existing development are needed to compute the one-foot rise. In contrast, mapping of a no-rise floodway is less complicated since it assumes that most of the floodplain is needed to convey flood flows. Thus, only outlying areas (e.g., tributary valleys) are omitted from floodway boundaries. Relatively accurate estimates of a no-rise floodway based on topography can often be made without detailed modeling.

Problems with Definition Criteria and Maps for Coastal High Hazard Areas

Most states and coastal communities have adopted NFIP standards that require elevation to the 100-year base flood elevation for coastal areas, if data on the elevation is available. Communities in the regular phase of the NFIP and with identified coastal high hazard (velocity wave) areas must ensure that construction is "located landward of the reach of the mean high tide."¹⁵ However, under NFIP standards, structures may be built in wave velocity zones and erosion areas if protection is provided to the 100-year flood elevation and a registered architect or professional engineer certifies that the structure is "securely anchored to adequately anchored pilings or columns in order to withstand velocity waters and hurricane wave wash."¹⁶ Structures may be elevated by construction on pilings, columns, or piers.

Special restrictions for coastal high hazard areas have been only partially implemented because many NFIP maps do not designate velocity zones. Moreover, as discussed earlier, wave heights have not been considered in establishing mapped 100-year base flood elevations. Water-related erosion, which poses a more serious threat than flooding near bluffs and on some beaches, is also omitted from maps and the NFIP's regulatory standards.

Because of these deficiencies, some states have adopted standards that exceed the NFIP's for protection of development in coastal high hazard areas. For example, in 1970, Florida adopted interim legislation requiring that construction begun after July 27, 1970, be at least 50 feet inland from the mean high water mark to protect structures from erosion and waves. This statute was amended in 1971 to provide a variable "engineered" setback line for high energy beaches.¹⁷ The Hawaii legislature adopted a beach setback line in 1968.¹⁸ Rhode Island prohibits development on most dunes, beaches, and wetlands under a variety of laws.¹⁹ Regulations cover erosion areas and require a minimum structural elevation of six feet above the base flood elevation. Since 1978, Delaware has required protection against waves for development in beach zones. Many of these states have complained that less restrictive NFIP standards undercut their programs.

A variety of more restrictive local programs were also adopted.

- San Diego and Santa Barbara, California require sufficient setbacks from eroding bluffs to provide protection for the expected life of the structure. Where erosion rates are three feet per year, for example, a 300-foot setback is required for a structure expected to last 100 years. Regulations are usually part of more comprehensive coastal zone management provisions required by the California Coastal Zone Acts of 1972 and 1975.
- Washington communities require erosion setbacks as part of the state's Shoreland Zoning Act of 1971, which applies to all coastal beaches and floodplains.²⁰ All communities are required to prepare "master programs" consistent with standards of the Department of Environmental Regulation. The Department pre-

pared a detailed atlas of coastal areas showing 100-year flood elevations, erosion areas, and wave hazard areas to assist communities in their planning and regulation.

- Some Florida jurisdictions such as Sarasota County adopted coastal setback lines for distances of 25 to 150 feet from the high water mark to protect against erosion and wave action. Community setback lines usually coincide with setbacks defined by the state.
- At least 10 Michigan communities along Lake Michigan adopted erosion setback lines consistent with standards of the Michigan Department of Natural Resources. The 1971 Shoreline Act²¹ authorized the Department to define high risk erosion areas, flood areas, and "environmental" areas. The Department conducted a detailed inventory of erosion areas based on air photo sequences dating from 1938 to the present. Field inspections were also used to define a setback line reflecting a 30-year erosion recession rate. After definition, the state required that state or local construction permits be granted only for areas behind the setback line.

Inadequate Protection for Dunes and Wetlands

The NFIP requires that coastal communities with defined coastal high hazard areas adopt regulations prohibiting "man made alteration of sand dunes and mangrove stands...which would increase potential flood damage."²² Protection is required because FEMA recognizes that dunes and mangrove stands reduce wave heights and water-related erosion. However, the NFIP does not provide for the mapping of dunes and mangroves and has not effectively monitored the adoption of regulations for their protection. Consequently, the extent and results of adoption are uncertain.

Several states and many localities have adopted dune protection measures meeting or exceeding NFIP standards. Maine prohibits alteration of dunes under a coastal wetland act.²³ Rhode Island and North Carolina regulate dune alteration under coastal zone management acts.²⁴ Georgia and North Carolina have adopted dune protection legislation. Florida has adopted the setback line discussed above. Many communities in these and other states regulate or prohibit alteration of either primary or both primary and secondary dune systems.

- Wrightsville Beach, North Carolina, has setback lines and dune protection ordinances.
- Rhode Island coastal communities such as South Kingston, Warwick, and Westerly have dune protection regulations.
- Beach Haven, Avalon, and many other New Jersey communities adopted beach setback and dune protection regulations following the severe winter storm of March 1962, which destroyed much of the primary dune system along the coast. Beach setbacks have generally been combined with dune restoration and protection, such as planting grasses.

Inadequacies in Combined Flood Hazard and Stormwater Management

Prior to 1970, floodplain regulations in urban areas were rarely adopted for small streams and watercourses. Future urbanization was not considered in calculating flood flows. Subdivision regulations usually required that subdividers install drainage systems sufficient to accommodate the discharge of the 5- to 15-year storm, but not larger events.

In the 1970s, many urban and metropolitan areas adopted floodplain regulations for small rivers and creeks based on flood studies that included projected urbanization of watershed areas. These floodplain regulations and stormwater management ordinances usually require developers to install stormwater management measures maintaining peak runoff levels or increasing runoff by no more than a specified amount. Above-ground drainage systems for the 100-year flood as well as below-ground storm sewers for small floods (e.g., 5- to 10-year storms) are required. Onsite detention areas or "compensatory storage" are also usually required. Some ordinances permit developers to contribute to a general drainage fund rather than require a drainage system and detention areas. The community uses this fund to construct and maintain common drainage systems and detention areas. The funds may also be used for stream channelization projects, levees, and other flood control measures.

Some communities or developers have also carried out detailed mapping and hydrologic studies on a watershed basis for drainageways and

small streams not included in the NFIP flood studies. Map scales range from 1"=500' to 1"=200' with 1' to 4' contour intervals. "Urbanized" watershed conditions are assumed in flow calculations. If floodways are not mapped, setbacks of 50 to 200 feet from small streams and drainageways are sometimes required.

The community or developer typically computes stormwater runoff prior to subdivision approval. Some communities have prepared computer models to help evaluate impact. Examples of effective stormwater management are:

- Baltimore County adopted both floodplain and stormwater management regulations requiring onsite detention. Some of the funds for flood-related drainage repairs were combined to create a \$27 million floodplain acquisition program.
- Alexandria, Virginia, adopted sophisticated stormwater management regulations for Four-Mile Run. A computer model prepared by the Corps of Engineers calculates the effect of proposed development on storm runoff.
- Montgomery County, Maryland, adopted a stormwater management ordinance that requires onsite detention to prevent runoff from exceeding the quantity expected from a 10-year storm. Rockville, Maryland, also requires that stormwater held in onsite detention be released at no greater than a 2-year rate of flow.
- King County, Washington, has studied and is adopting a stormwater management program that requires a utility fee (based on quantity of discharge) for discharges into the county drainage system. Arvada, Colorado, also adopted a drainage fee ordinance. In addition, developers must provide compensatory storage and must deed 6% of the land to the city. Santa Barbara County, California, adopted a similar "benefit assessment" ordinance.
- Howard County, Maryland, requires detailed flood studies if a subdivision is partially within a floodplain or if the watershed drainage covers more than 50 acres. The county also adopted a phased-growth management policy to prevent overburdening of streams and comprehensive subdivision design standards to encourage clustered development and preserve as much open space in the floodplain as possible.
- Lake County, Illinois, adopted a natural resources protection plan prohibiting all floodplain development. In addition, runoff from other watershed areas must not be increased above certain "performance" levels. Maximum

limits are placed on the areal extent of impervious surfaces and development densities. Many towns in Bucks County, Pennsylvania, have adopted similar performance controls.

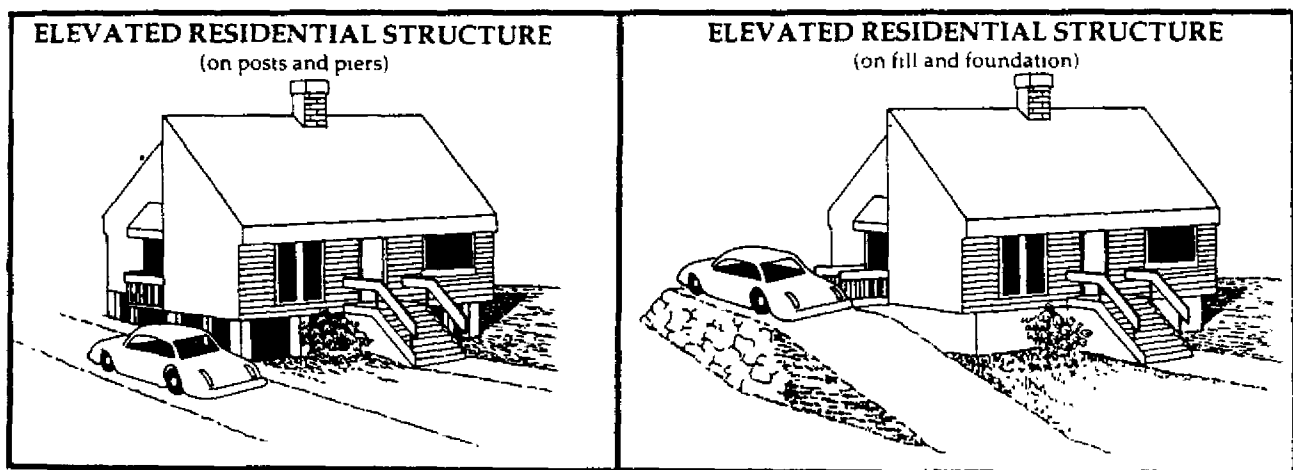
Comprehensive stormwater management has encountered problems. Some onsite detention has increased rather than decreased flood peaks where natural flood peaks occur slowly. Debris and sediment have clogged underground detention areas. Runoff techniques that did not include flood storage were difficult to integrate into traditional floodway/flood fringe regulations.

Limitations of Flood Protection Measures

Implementation of floodplain regulations was hindered in the 1970s by uncertainties about the long-term effectiveness of elevating structures on pilings in wave velocity zones and floodproofing industrial and commercial buildings.

Elevation on fill. State and local governments favored elevation on fill for inland areas in 1970 when Volumes 1 and 2 of Regulation of Flood Hazard Areas were written. Even though it is not favored by FEMA because it eliminates flood storage, many states and localities continue to favor this approach for inland areas. Elevation on fill up to a few feet is relatively inexpensive and permanent. In addition, it has a built-in safety factor: if the base flood elevation is exceeded, often only minor flooding occurs in a structure elevated on fill, causing limited damage. By contrast, a floodproofed structure will be flooded to the full flood height or it may collapse if the base flood elevation is exceeded.

Despite its advantages in low velocity inland areas, fill destroys wetlands and flood storage capacity. It is subject to erosion in high velocity flow areas and it creates a mounded effect, which, even with skillful landscaping, may be aesthetically unattractive, especially if existing structures were built at substantially lower elevations.



ELEVATED STRUCTURES

Source: Missouri Department of Public Safety, Disaster Planning and Operations Office

Elevation on pilings and other open works. The NFIP, state, and local programs prefer elevation on wooden, concrete, or steel pilings or other "open works" such as walls, columns, or piers in most coastal and inland floodway areas. Elevated structures offer less resistance to waves and flood flows. Pilings and other open works are not as easily eroded as fill. Open works have negligible effects on conveyance and flood storage, and are less disruptive of wetlands.

However, open works are also subject to limitations. In coastal areas, the elevated structure and its supports must be designed to withstand not only the stress of waves and swiftly flowing water (often not considered), but also hurricane winds of 70 to 200 miles per hour. Inadequately braced structures may tilt and fall. Buildings may also be blown or swept off the open works if not adequately secured by bolts or tie-downs. Pilings without deep footings in wave and high velocity flow areas may be undermined by erosion. Wood pilings may also rot or be weakened by termites. Structures elevated on open works become inaccessible during flooding, complicating the evacuation of occupants and rendering the structure unusable.

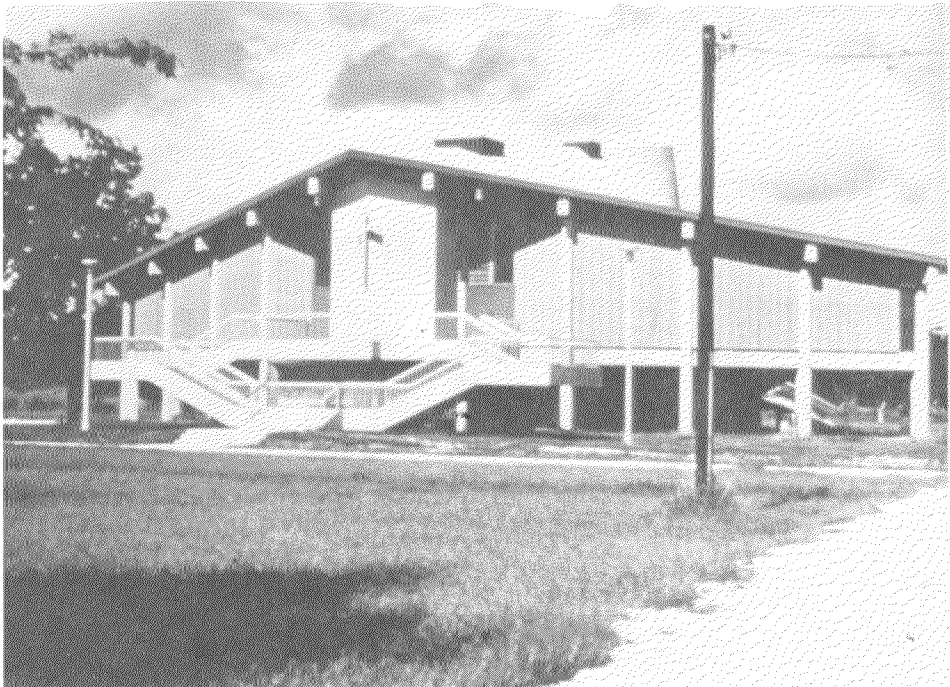
As discussed in Chapter I, Hurricane Frederic dramatically revealed problems with elevation on inadequately designed pilings. Winds and waves almost totally destroyed the first tier of structures along 36 miles of beach, 70% in the second tier, and 50% in the third tier. Most structures had been elevated on pilings, ostensibly to the 100-year flood elevation, but without consideration of waves or erosion.

Floodproofing. Design standards for floodproofing advanced during the 1970s, although the effectiveness of these designs during actual flood conditions is still questionable. The NFIP and most state and local regulations permit the construction of commercial and industrial but not



Building elevated on fill in Soldiers Grove, Wisconsin.

Photo by Jon Kusler.



Building elevated on pilings in a coastal area.

Photo by Jon Kusler.

residential buildings below the base flood elevation, if adequately flood-proofed.

Prior to 1970, floodproofing was not widely applied because engineers and architects were not familiar with floodproofing techniques and little had been done to develop specific design standards. In 1970-1971, the Corps of Engineers published a document entitled Floodproofing Regulations,²⁵ which established the first detailed floodproofing guidelines. FEMA and others subsequently developed numerous floodproofing handbooks.²⁶

Most floodproofing during the 1970s was "dry floodproofing." This type of floodproofing is designed to keep the flood waters out of the structures. To prevent inundation, floors and walls were reinforced and sealed. Basements were prohibited unless they also were reinforced and sealed; and doors, windows, and other openings were reinforced and fitted with emergency closures.

Despite widespread use of dry floodproofing, there has been little field documentation of its effectiveness. Preliminary evidence suggests that because of water pressure, it is impractical to dry floodproof most structures higher than 2 or 3 feet. Waterproofing has also proved difficult because of small leaks along doors and in foundations. These may be serious when flooding is of long duration. Sump pumps may be used to remove residual seepage, but this requires continuous use of electrical power which is often only provided on an emergency basis during floods and thus is undependable. The long-term effectiveness of dry floodproofing that requires temporary closures is also questionable without continuous monitoring, training, and practical exercises in their use. Temporary closures must be kept at hand.

To a lesser extent "wet floodproofing" was also used during the 1970s.²⁷ This method intentionally allows floodwaters to enter basements



This building combines five dry floodproofing techniques: reinforced concrete walls, an emergency flood door to prevent water entry, bricked-in window openings, elevated utility lines (near top of photo), and ladder for access through the roof.

Photo source: U.S. Army Corps of Engineers, St. Paul District.

or first floors or uses fresh water to flood those areas to counteract floodwater pressure and prevent the intrusion of sediment-laden floodwaters. Wet floodproofing is designed mainly to protect the structural integrity of a building by permitting damage to electrical systems, building contents and interior walls. Measures must be taken to permit rapid removal or floodproofing of machinery, materials, and other damageable contents. Although conceptually sound, flooding a building to equalize interior and exterior pressures requires careful application and continuous monitoring of the rate at which internal and external flooding takes place in order to prevent structural damage. In addition, if water free of sediment and other pollutants is to be used for intentional flooding, a continuous source of fresh water must be available.

Federal Subsidies that Undermine Floodplain Regulations

Federally subsidized flood insurance and the standards of the NFIP have encouraged state and local adoption of floodplain regulations, but may also have encouraged floodplain development.²⁸ Federal funding of flood control works with an 80% to 100% federal subsidy also encourages development and discourages nonstructural flood loss reduction techniques which shift loss-bearing to the floodplain occupant. Development is also supported by federal principles and standards for flood control measures which permit the Corps and other agencies to include the highest intensity future floodplain uses as economically feasible elements in the cost/benefit analyses. At the same time, limited or no benefits can be claimed for open space use or maintenance of natural resources. Many of the aggressive floodplain management programs that incorporated regulations and other elements were developed by communities during the 1970s only after federal agencies rejected structural solutions due to problems with soils, topography, or unfavorable cost/benefit ratios.²⁹

Regulations Combined with Other Techniques

Many communities and some states combined regulations with other management techniques to reduce future flood losses, provide areas for public use, and accomplish broader floodplain management and land use objectives.

Acquisition

An estimated several thousand communities acquired a portion of their floodplains for park, parkway, wildlife, conservation, agricultural, or other environmental or social uses.³⁰ Acquisition complements regulations by providing total protection for critical environmental areas such as habitat for threatened and endangered species. It also makes the land available to the public for hiking, picnicking, or other recreational purposes.

Acquisition is more permanent than regulations--once completed it is not so subject to the whim of local legislative bodies. However, it is costly if the purchase is made in fee. Typical floodplain acquisition costs in rural areas range from \$300 to \$1,000 an acre. Urban costs often range from \$1,000 upward, depending on a wide range of variables.

Localities have acquired the most land and have held it in fee. However, some communities such as Glastonbury, Connecticut, and East Hampton, New York, have acquired easements to reduce costs, continue lands on the tax rolls, and avoid maintenance responsibilities. Private donations of land as gifts or bequests have also been important, particularly for wetlands.

Most acquisition has been voluntary although a few communities have used eminent domain powers. Local governments have frequently used federal funding sources such as the Department of Interior's Land and Water Conservation Fund and HUD's Community Development Block Grant Program to help pay acquisition costs. State funding sources such as

the New Jersey Green Acres Program have also played important roles in a few states.

- Milwaukee County, Wisconsin, acquired most of the county's floodplain as well as its Lake Michigan bluff area for part of its greenway and park corridor system. Milwaukee was one of the first cities in the nation to regulate floodplains, starting in 1936. Acquisition was also begun in the 1930s.
- Sacramento County, California, combined regulations and acquisition to protect the floodplain and provide public recreation areas along much of the county's American River floodplain. Altogether, the city, county, and private organizations have acquired about 3,000 acres along 23 miles of river. A variety of state, local, and private funding sources were used.
- Scottsdale, Arizona, acquired a 4.6 mile-long greenbelt floodway along Indian Bend Wash which runs through the city. A bond issue and the Corps provided the funding.
- In cooperation with the Twin Cities Metropolitan Council, Ramsey County, Minnesota, has acquired much of the Mississippi River floodplain in the town of Lilydale. An estimated \$4.4 million in project funding was provided by local and metropolitan sources.
- Dallas, Texas, acquired more than 2,500 acres of floodplain along the Elm Fork of the Trinity River and Oak Creek at an estimated total price of \$4.5 million. Funding was from a variety of sources, including local bond issues, the Land and Water Conservation Fund, and HUD open space programs. Some of the floodplain was privately donated to the city.
- The Brandywine Conservancy (a private, nonprofit Pennsylvania corporation) acquired 400 acres in fee and 4,000 acres of easements for critical environmental areas in 20 communities since 1967. Much of the acquired land is floodplain along the Brandywine River. Negotiation with landowners and limited purchase has been applied.

State and federal authorities have also acquired floodplain areas, but on a more limited scale. For example, the Corps of Engineers is purchasing 8,500 acres of floodplain wetlands along the Charles River near Boston to preserve valley storage and prevent increased flood heights in the Boston area. The Corps and the state have agreed that other flood storage areas along the Charles will be regulated by local governments.



Floodplain subject to conservation easement, Black Earth Creek,
Wisconsin.

Photo by Jon Kusler.

Regulations and Public Facilities Planning

In the 1970s, all levels of government made progress in applying flood hazard mitigation policies to new public infrastructure--roads, sewers, bridges, water supply systems, electric lines and natural gas pipelines. These facilities are not only subject to costly flood damages but influence the location and intensity of private floodplain development. State and local governments have long had the authority to refuse or limit infrastructure in floodplain areas because of their high costs and the threat of recurrent flood damages. Until recently, however, few have done so because of pressure from landowners and lack of coordination between regulatory and public works programs.

The federal executive orders on floodplain management and protection of wetlands issued in 1977 and the NFIP standards pertaining to public uses gave impetus to state and local initiatives. The orders require that federal projects and federally funded state and local projects be located outside the floodplain, unless no alternative exists. If none exists, early notice must be provided to the public and measures must be taken to minimize flood damages and harm to natural values.

Federal agencies are now in the process of implementing these orders. They are reviewing and revising earlier policies for extending facilities into floodplain areas. For example, the Environmental Protection Agency conditioned a sewer grant to Cape May, New Jersey on an agreement that they would limit sewer extensions in flood hazard areas.

Some state statutes and executive orders require control of public works in floodplain areas. The NFIP has required states to control public buildings in order to qualify for flood insurance. In response many states have adopted executive orders.³¹ Other states like New Jersey directly regulate state and local public works under floodplain regula-

tory statutes. Several states regulate public uses in specific hazard areas through coastal zone management statutes or executive orders. For example, in August 1980, Governor King of Massachusetts issued a beach and barrier island executive order prohibiting new construction in front of the dunes on barrier beaches and denying state aid for such activities, including rebuilding of existing structures.³²

Regulations and Flood Warning Signs

Some states and communities have erected flood warning signs to complement regulations. A single sign along a heavily traveled highway can do much to raise community awareness. Flash flood warning signs are used in Boulder, Colorado, and other Rocky Mountain front range communities. Warning signs have also been adopted by some coastal communities such as Shelter Island, New York. Signs that warn of the flooding threat and give flood heights and dates of past flood events are particularly effective.

Regulations and Tax Incentives

Real estate and other tax incentives have been combined with regulations to encourage open space uses. For example, the New Jersey state floodplain regulatory statute requires that local property tax assessors consider state regulations.³³ A Massachusetts statute authorizes reduced property taxation for landowners who execute conservation restrictions for floodplains, wetlands, or other similar areas.³⁴

At least 43 states offer broad real estate tax incentive programs for lands in agriculture, forestry, and certain other open space uses.³⁵ Undeveloped floodplains may qualify for reduced taxation pursuant to many of these statutes. Under most statutes, lands entered into programs are assessed at open space value rather than potential development value. If owners subsequently decide to develop the land, they usually must pay taxes (calculated at full development potential) plus interest and, in

some instances, a penalty. Despite widespread adoption, open space tax provisions have been only partially successful since many landowners wish to hold their lands in an open condition only temporarily.

California has experimented most extensively with open space tax incentives for agricultural and other open space lands.³⁶ In this state, lands must be both entered into the open space taxation program and regulated prior to receipt of benefits. Other states with active programs are Maryland, Minnesota, Vermont, and Wisconsin.

Federal and, to some extent state, income tax laws also encourage open space protection. Individuals who donate such lands or open space easements to government units or private nonprofit corporations may deduct the value of the contributions from ordinary income as "charitable contributions."³⁷ Under present federal tax laws, an individual may deduct up to 30% of adjusted gross income in a tax year, with carryover deductions in the succeeding five years.

Private donations to receive income tax deductions are particularly attractive if a parcel of land has substantially appreciated since original purchase or development is contrary to regulations or considered inadvisable by the individual or corporation. The value of the charitable contribution is the present full market value of the land. For an individual or corporation with substantial income, it may be more profitable to donate than to sell floodplain parcels.

Regulations and Public Education

Public education has been essential to developing and implementing floodplain management programs. Education during the 1970s has included distribution of flood maps and brochures; workshops and training sessions; marking flood hazard areas; and one-to-one discussions with floodplain property owners, insurance agents, lenders, lawyers, and others involved in floodplain decision making. State floodplain management programs



Sand Dune Restoration and Protection Project, Avalon, New Jersey. Avalon has combined regulations with acquisition, a sand dune restoration program, and public education in an award-winning beach protection program.

Photo by Jon Kusler

have developed and distributed brochures, manuals, and model ordinances.³⁸ States have also conducted floodplain management workshops for local governments, including information on floodproofing and administration of regulations.

One-to-one consultations have been particularly effective at the local level. For example, members of conservation commissions in Concord and Lincoln, Massachusetts, visited landowners to advise them of wetland and floodplain designations and to explain the rationale for the restrictions. Other communities have sent copies of floodplain maps to all property owners. Avalon, New Jersey, included a brochure on dune protection with tax bills sent to property owners throughout the community.

Other Techniques

Regulations have also been combined with other approaches such as flood control works, evacuation plans, and flood warning systems. These are discussed in the next chapter.



The Conservation Foundation and Florida Audubon Society conduct a floodplain management training session in St. Augustine, Florida, with funds from FEMA, in May 1979.

Photo by Jon Kusler.

CHAPTER II

Footnotes

1. The concept of "wise use" of the nation's floodplains, taking into account not only flooding but also other, broader values, is contained in the Water Resources Council's A Unified National Program for Flood Plain Management. This document calls for "continuing efforts that seek to reduce and keep flood losses at acceptable levels while recognizing, preserving, and restoring the floodplain's natural values through wise use of water and related land resources."

Regulations of the National Flood Insurance Program, 41 Fed. Reg. 46,964 (1976), also provide that "in formulating community development goals and in adopting flood plain management regulations, each community shall consider at least the following factors--

- (1) Human safety;
- (2) Diversion of development to areas safe from flooding in light of the need to reduce flood damages and in light of the need to prevent environmentally incompatible flood plain use;"

2. Sheaffer and Roland, Inc. (1981) examined 23 communities to quantify the economic, social and environmental effects of regulating the 100-year floodplain. Effects of floodplain regulations were evaluated by projecting development for 1980 and 1990 under three scenarios: (1) no regulations, (2) moderate regulations similar to the current FIA regulations, and (3) stringent regulations forbidding new developments and substantial improvements to existing structures. Some of the results of the study may be summarized as follows:

- (1) Average annual flood losses were projected to increase sharply (29% by 1980, 71% by 1990) with no regulations. Under moderate regulations, losses would increase somewhat. Under stringent regulations losses would decline 1% by 1990.
- (2) With no regulations, the number of housing units in the floodplain would increase by 13% by 1980 and 35% by 1990; and population would increase in the 100-year floodplain 12% by 1980 and 29% by 1990. With moderate regulations, housing units would be increased somewhat by 1980 and 1990. With stringent regulations, housing units in the 100-year floodplain would decline 1% by 1980 and 6% by 1990.

3. Burby and French concluded that

Flood plain land use management regulations, including those required by the NFIP, have had little effect on the rate of flood plain invasion. . . . While staff and funding commitments may indicate that communities are taking steps to see that new construction is at least elevated or flood-proofed so that some protection against flood damage is provided, these data clearly show that local flood plain land use management is not halting the continued invasion of flood plains. Furthermore, fostering regulations that are focused on the design of

development, such as local regulations required for participation in the National Flood Insurance Program, does not necessarily lead communities to restrict floodplain use (1981, p. 294).

4. See discussion at pages 192-195.
5. 24 C.F.R. § 1910.3 (1976).
6. See, for example, Sheaffer (1977) and Sheaffer and Roland, Inc. (1980).
7. Floods greater than the 100-year flood caused 61% of the losses experienced in the United States between 1959 and 1974 (Sheaffer *et al.*, (1976, p. 49).
8. For example, when flooding exceeded levees designed to withstand a 100-year flood in Jackson, Mississippi, in 1978, damage to backing structures approached 1/2 billion dollars.
9. See footnote 47, Chapter I.
10. See discussion at footnote 55, Chapter I.
11. 24 C.F.R. § 1910.3 (1976).
12. *Id.* § 1910.3(d).
13. *Id.*
14. The National Science Foundation (1980), concluded that "[b]uilding in floodways is continuing and increasing the property and lives at risk." The report recommended that

[f]ederal, state, and local program standards should be changed to prohibit any new development in floodway areas which will increase flood elevations. There may be circumstances requiring exceptions to this prohibition. In such circumstances, a promising solution is for the developer to purchase all necessary property rights from all adversely affected property owners for increased flood damage, increased building costs, increased flood insurance and other costs (p. 215).
15. 41 Fed. Reg. 46,964 (1976).
16. Fla. Stat. Ann. § 161.052 (West Supp. 1982).
17. Fla. Stat. Ann. § 161.053 (West Supp. 1982).
18. Hawaii Rev. Stat. §§ 205-32 to 205-37 (1976 and Supp. 1980).
19. See R.I. Gen. Laws §§ 46-23-1 to 46-23-16 (1980), §§ 2-1-13 to 2-1-17 (1976), and 11-461-1 (Supp. 1980).
20. Wash. Rev. Code Ann. §§ 90.58.010 to 90.58.930 (Supp. 1981).
21. Mich. Comp. Laws Ann. § 281.631 (1979).

22. 24 C.F.R. § 1910.3 (1976).
23. Me. Rev. Stat. Ann. tit. 12 §§ 4701 to 4758 (1981).
24. R.I. Gen. Laws §§ 46-23-1 to 46-23-16 (1980); N.C. Gen. Stat. §§ 113A-100 to 113A-134 (1978).
25. Office of the Chief of Engineers, U.S. Army (1973).
26. See bibliography to Chapter II.
27. See Sheaffer and Roland, Inc., (1979).
28. See footnote 55, Chapter I.
29. Examples include Hilo, Hawaii; Prairie du Chien, Wisconsin; and Soldiers Grove, Wisconsin.
30. For discussion of floodplain acquisition see Ralph M. Field Associates (1981), and references in Chapter III.
31. E.g., Rhode Island, Executive Order No. 35, October 23, 1978; Wisconsin, Executive Order No. 67, November 26, 1973; California, Executive Order B-39-77, November 26, 1977.
32. Commonwealth of Massachusetts, Executive Order No. 181, Barrier Beaches, August 13, 1980.
33. N.J. Stat. Ann. § 58:16A-61 (1982) provides:

Local assessors shall consider the impact of rules or regulations issued pursuant to this act in establishing full value of lands designated as floodways or as flood fringe areas.
34. Mass. Gen. Laws. Ann. ch. 59, § 11 (West Supp. 1981); ch. 184, §§ 31-33 (West Supp. 1981). See also N. Y. Envir. Conserv. Law § 25-0302-2 (McKinney Supp. 1981-1982); Conn. Gen. Stat. Ann. § 22a-45 (1981).
35. Council on Environmental Quality (1976).
36. *Id.* See Cal. Gov't Code § 51201 et seq. (West 1966).
37. See 26 U.S.C. § 170(b)(1)(c) (Supp. 1977); 20 U.S.C. § 2055(e)(2) (Supp. 1977); 26 U.S.C. § 2522(a)(2) (Supp. 1977).
38. See the many educational materials listed in the bibliography of Appendix A, Strengthening State Floodplain Management.

CHAPTER III

REDUCING LOSSES TO EXISTING USES

Overview

In the 1970s, floodplain regulations, when applied alone, were largely ineffective in reducing flood losses to the 4.5 to six million¹ structures already located in the 100-year floodplain except after severe floods. But they encouraged some voluntary floodproofing by putting landowners on notice as to flood hazard protection needs and elevations. After disasters progress was made in prohibiting alterations and rebuilding in excess of a stated amount. Regulations were used to encourage relocation with flood insurance payments, disaster grants, and loans conditioned on compliance with standards. They were also imposed to establish moratoria on rebuilding until detailed flood maps and recovery and relocation plans were completed.

To further reduce flood losses to existing uses in the 1980s, regulations must be integrated into, or carefully coordinated with, broader community zoning, building codes, housing codes, sanitary codes, and other regulations that apply to existing uses. Amortization provisions should be adopted in some circumstances. Regulations should be coordinated with predisaster planning. In floodways, "substantial improvement criteria" in zoning and other regulations should be clarified and tightened. After a disaster, strict interim or long-term regulations should be applied. Implementation will require not only improvements in state and local regulations, but also federal technical and financial aid, and revisions in federal flood insurance and disaster assistance to act as incentives for private hazard reduction.

Concerted efforts to address existing structures are essential if long-term flood losses are to be reduced. Most existing structures were

TABLE 4

TECHNIQUES TO REDUCE LOSSES TO EXISTING USES

Adoption of Interim Regulations After a Disaster to Prevent Rebuilding Until Flood Studies, Postdisaster Planning, Acquisition, Other Measures are Undertaken

Adoption of Long-term, Upgraded Regulations After a Disaster

Adoption and Enforcement of Regulations with Nonconforming Use Provisions

- Regulations requiring floodproofing, etc., when structures are abandoned or damaged.
- Amortization provisions requiring short-term or long-term removal of nuisance uses in floodways, floodproofing

Floodproofing of Existing Structures

- Raising structures
- Temporary or permanent waterproofing
- Wet Floodproofing
 - Structural design changes
 - Water resistant materials replacements
 - Operation of buildings, including allocation of space

Emergency Evacuation

- Flood forecasting
- Flood warning
- Evacuation planning

Public Acquisition and Relocation

- Purchase, "bargain" sales, land exchanges
- Removal of existing structures

Reduction of Storm Runoff

- Land treatment
- On-site storage requirement

Disaster Assistance and Flood Insurance Conditioned Upon Mitigation

- Floodproofing or relocation after a disaster
- Adoption of flood control measures

Flood Control Measures

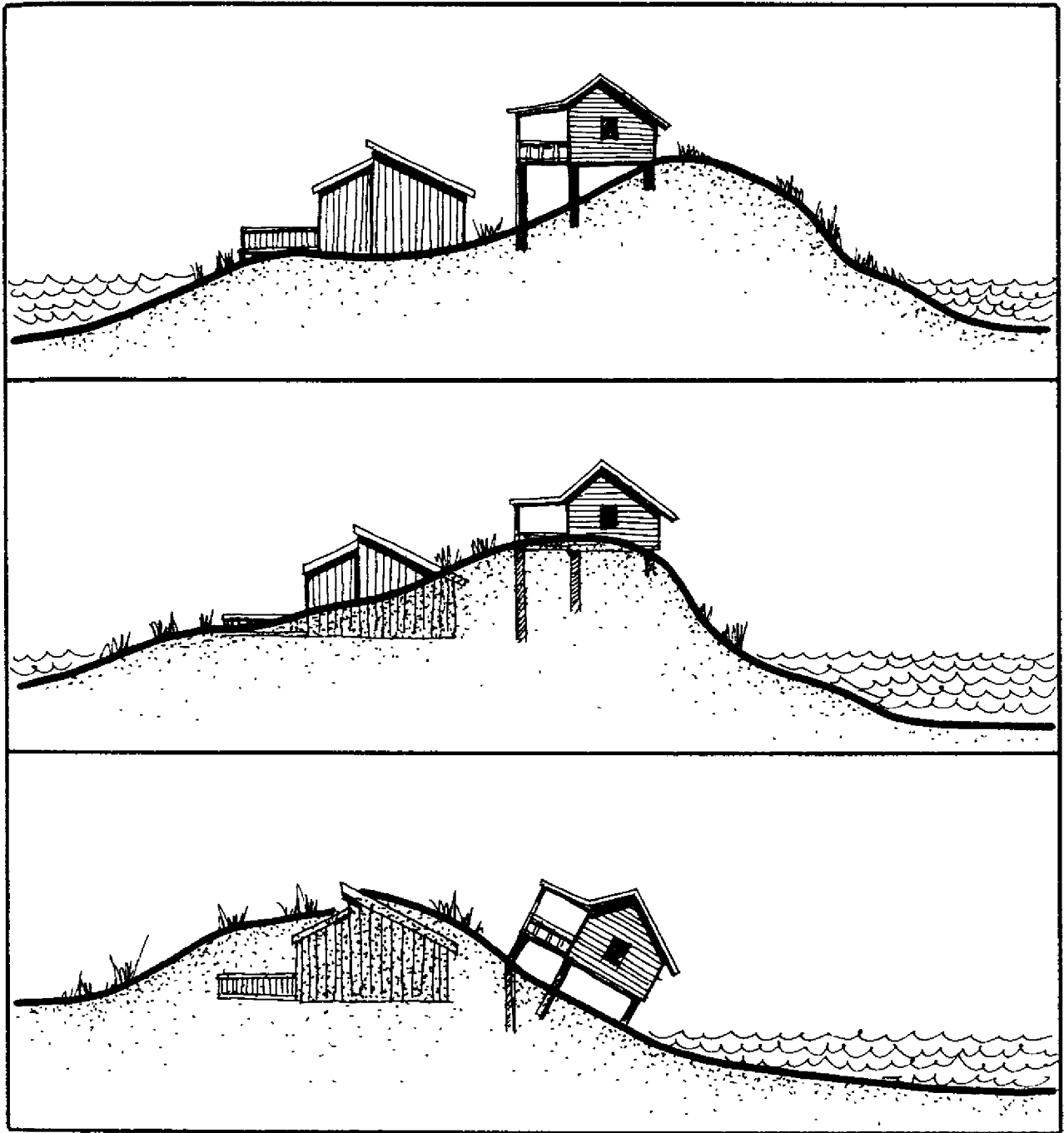
- Dams
- Dikes, levees
- Channel straightening
- Artificial dunes, beaches

built before state or local regulation of flood-prone areas and have little or no protection against flooding. In coastal areas, an estimated two to three million structures are located one to 10 feet below the 100-year still water flood elevation. In 1980, four coastal metropolitan areas (Houston/Galveston, New Orleans, Tampa/Fort Myers and Miami/Fort Lauderdale) alone accounted for 680,000 flood insurance policies, or 37.8% of the national total.² In many coastal areas the entire floodplain is developed.

Structures below flood elevations are often damaged by flooding, repaired, and damaged again. A study of repetitive flood insurance claims in 1979 revealed that at least 883 structures had two flood insurance claims within five years, with damage at least 25% of structural value.³ From January 1, 1972 to August 31, 1979, three or more major flood disasters were declared in 351 communities.⁴

In urbanizing areas, flood threats to existing structures are increasing. Urbanization increases peak flows from two to six times for smaller floods.⁵ Watershed development increases the rate of runoff and decreases infiltration. Floodplain development eliminates flood storage, thereby increasing flood heights. A regulatory "floodway" with development in fringe areas also increases flood heights up to one foot, thereby increasing damages to structures in the 100-year floodplain. In many riverside cities, sedimentation in reservoirs and stream beds is worsening flood conditions.

Combined flooding and erosion threats to existing structures are increasing on barrier islands (e.g., Cape May, New Jersey) due to landward movement of the islands at rates of 300 feet or more per century. Erosion and flooding problems are also becoming more serious in bluff areas (e.g., the California coast, the Lake Michigan shore), where struc-



MIGRATION OF BARRIER ISLANDS

tures built 50 years ago at some distance from the bluff are now at the edge due to recession.

Private flood losses are not the only problem resulting from the many damage-prone structures in the floodplain. Roads, sewers, water supply systems, and other public services constructed to serve these structures are severely and repeatedly damaged. Repair of a causeway to Dauphin Island, Alabama, damaged by Hurricane Frederic in 1979 cost federal taxpayers \$39 million. Repair of roads and bridges damaged by flash flooding in Big Thompson Canyon, Colorado, cost federal taxpayers \$28 million.

Loss of tax revenue, loss of jobs, and subtle pressures for publicly funded flood control works are other consequences. Moreover, the presence of extensive nonconforming uses often undermines regulations for new uses. It is difficult to enforce regulations for new uses in areas with dozens or hundreds of adjacent nonconforming structures.

Lack of success in applying regulations alone to reduce losses to existing uses has been due to these factors.

- (1) Nonconforming use provisions have not been adequately enforced due to ambiguities in regulatory provisions and the unwillingness of many state agencies and local governments to impose additional burdens upon flood-damaged property owners.
- (2) Nonconforming use provisions have not been sufficiently tailored to highly varied flooding problems and the flood protection needs of particular types of nonconforming uses.
- (3) Government subsidies for flood control, disaster assistance, and flood insurance provide little incentive for private remedial flood protection.

Nonconforming Use Provisions

State regulatory programs do not require flood protection measures for existing uses except where substantial rebuilding or repair takes place or a damaged structure is abandoned. Local regulatory programs have generally adopted the minimum standards of the NFIP, which also do

not require modifications to existing uses unless "substantial improvements" take place.⁶ Substantial improvements are defined to include "repair, reconstruction, or improvement of a structure, the cost of which equals or exceeds 50% of the market value of the structure either, (a) before the improvement or repair started, or (b) if the structure has been damaged and is being restored, before damage occurred."⁷

Although minimal, these provisions have also not been vigorously enforced because of political pressures and difficulty in determining when the triggering "50%" threshold has been crossed. In addition, the pre-flood value used as the basis for calculations is often difficult to obtain.⁸

After a flood, repairs or alterations are often made incrementally, with none exceeding 50% of the structural value in one year. Periodic additions to structures, none of which exceeds the 50% threshold, can double or triple structural values without provision of flood protection. Interior work, painting, and other finishing touches, which are expensive, are rarely included in calculations. Improvements to comply with health, sanitary or safety code specifications (e.g., a new roof, new plumbing) are also rarely included.

Local governments have been reluctant to regulate existing uses because some zoning enabling acts partially exempt existing uses.⁹ However, an increasing number of states have specifically authorized local governments to terminate nonconforming uses under certain conditions.¹⁰ For example, a Missouri statute authorizes counties to adopt "reasonable regulation for the gradual elimination of nonconforming uses from districts zoned for residential use."¹¹ A Minnesota statute authorizes county boards "to regulate and control or to reduce the number or extent of or the gradual elimination of nonconforming uses and occupancies."¹² Where properly authorized in states like these, local

regulations that control and amortize existing uses that are nuisance-like have been upheld by the courts.¹³

The problem, however, is more than legal; questions of equity and political acceptability are involved. It is one matter to require a landowner to elevate or otherwise protect a new structure where the elevation may add 5% to 10% to the cost of construction,¹⁴ but it is another to require the protection of existing structures where the cost of elevation may exceed 40% of existing value.

Despite these problems, some communities have reduced the flood vulnerability of existing uses through innovative nonconforming use provisions.

Brattleboro, Vermont, imposed regulations on a mobile home park in a high-risk floodplain. The regulations require owners expanding their operation outside of the floodplain to remove one home from the high hazard area to gain approval for three added at higher ground. Some communities have effectively combined regulations with public education to encourage private floodproofing. In Wayne Township, New Jersey, an education program for landowners has resulted in more than 50 homes being privately elevated to or above the 100-year flood level. In one neighborhood, code enforcement has eliminated about 75 out of 300 structures. Floodproofing has been required for all renovations, improvements, and additions to structures. In Soldiers Grove, Wisconsin, the community development office has provided financial and technical assistance to individuals wishing to floodproof their structures. For example, one home there was elevated six feet on fill after the 1978 flood. Total cost was approximately \$9,500 dollars, with one-half of this paid by the town and one-half by the landowner.

In 1974, the county council in Howard County, Maryland, established a floodproofing loan program. Owners were authorized to borrow up to

\$6,000 for up to 20 years at an interest rate 1% higher than the average interest rate obtained at the most recent sale of Howard County obligation bonds.

In some areas, private industries have voluntarily floodproofed their structures, partly because of state and local public education efforts. The impressive experience of the Sprout-Waldron Division of the Koppers Company, Inc., of Lycoming County, Pennsylvania, is the subject of a film, slide presentation, and technical manual.¹⁵ In 1972 the main plant, which has 1,250 employees, was flooded to a depth of two to six feet, with flood damages exceeding \$3,300,000. The plant was shut down for three months and revenue losses exceeded \$2 million. To reduce future damages, the industry developed a flood preparedness plan that combined waterproofing in certain plant areas with removal of damage-prone contents from others. In September 1975, Hurricane Eloise flooded the plant to a depth of one to four feet. That time flood damages were less than \$231,000 and the plant was operating at over 80% of its capacity within 18 hours after the flood subsided.

Variations in Flood Loss Potential

Difficulties in reducing the flood damage potential of existing uses through a single nonconforming use formula are caused by variations in flooding threats, types of nonconformity, costs of remedial measures, and incentives for floodproofing or relocation.

Outer Fringe Areas

An estimated three to four million structures are located in outer fringe areas at elevations only one to two feet below the 100-year flood elevation. These include many structures along smaller streams and drainageways and at the periphery of major riverine and coastal floodplains. A 100-year flood may cause minor damage, particularly if the

water velocities are low, flooding is of short duration, and warning time is ample. But damages may be substantial for structures with basements containing heating and air conditioning systems, washers and dryers, recreation and storage rooms, or living quarters. In some instances, basements may collapse, endangering the lives of any occupants and damaging or destroying the remainder of the structure.

For structures in these outer fringe areas, damages may be reduced by temporary or permanent dikes and levees, stream channelization and straightening, floodproofing of structures and facilities, flood warning systems, and evacuation plans. At modest cost, small structures without basements may be elevated on fill, pilings, concrete blocks, or concrete foundations. However, elevation of larger structures or small structures constructed of stone, brick, masonry, or concrete is often prohibitively expensive.

Although the greatest potential for floodproofing occurs in outer fringe areas, the incentives are also smallest. Subsidized flood insurance payments give little incentive for private floodproofing. Flood insurance payments of up to \$185,000 may be made for most residential structures and up to \$60,000 for contents for communities in the regular flood insurance program. Structures are rarely damaged more than 50% of their value and, as a consequence, do not require floodproofing as a condition of rebuilding.

Commercial establishments in outer fringe areas have a greater incentive to mitigate flood damage because flood insurance payments for structural damage to a small business cannot exceed \$250,000. The amount usually covers only a small portion of the structural damage that may occur to a large commercial structure. Coverage for damage to inventories cannot exceed \$300,000 which is only a small portion of many inventories.

In addition, commercial and industrial establishments may lose substantial income when forced to close.

Fringe Areas Subject to Greater Flood Heights

An estimated several million additional structures are located in more seriously flooded areas, particularly along the coast. Some of these are behind low-lying dikes and levees that provide limited protection. Inundation of three to ten feet may be expected during a 100-year flood, with more frequent lower inundation from small floods. Although the anticipation of serious flood damages may create greater incentive for floodproofing, the technical and economic feasibility of elevating or floodproofing these structures to protect from a 100-year flood is less because of the depth of anticipated flooding and the increased hydrostatic pressures.

In a 100-year flood, residences in these areas often suffer structural damage approaching or exceeding 50% of their value, potentially triggering nonconforming use provisions. What is to be done with these structures? Some might be relocated, but not many in densely developed areas such as Miami. Elevation on fill or pilings may be possible for wood structures without basements. Dry floodproofing for such structures is rarely practical because hydrostatic pressures are substantial when inundation exceeds two to three feet. Wet floodproofing may be an alternative for brick, concrete, or concrete block structures.

Structures in Inland Floodways and Coastal High Hazard Areas

An estimated 300,000 to 500,000 structures are located in riverine floodways and coastal high hazard areas. Because of the severity and repetitive nature of floods, costs for disaster assistance and insurance to private structures and public facilities are greatest in these areas. Structures and fill in floodways are not only seriously damaged by flood-

ing, but they also increase flood heights and velocities on other lands. Structures in coastal high hazard areas and in floodways may be swept from their foundations, adding to the destructive force of flood waters.

Structures in these high hazard areas are often subject to nonconforming use provisions after a severe flood. Then relocation of existing structures is most attractive although not always practical. A flood insurance payment often compensates for only a portion of the loss. Dry floodproofing, however, is rarely sufficient. Studies by the Corps of Engineers show that it is very difficult to floodproof structures against a breaking wave of more than two or three feet, or inland flood velocities of 8 to 12 feet per second. Elevation on pilings and open works may be used in some instances, but damages to public facilities often continue and access may be cut off. Elevation is also impractical in severe erosion areas.

Federal Incentives and Disincentives

Federal flood hazard programs have provided little incentive for self-help measures. Federal flood control measures are typically 100% federally subsidized. Federal flood insurance at subsidized current rates provides slightly more incentive, but the federal government still bears much of the cost of flooding. A tightening of insurance rates to reflect actual risk, as now proposed by FEMA, would remedy this. Tight enforcement of the provisions of the Disaster Relief Act of 1974 would also help. That act requires that before receiving disaster assistance loans or grants, states and localities agree "that the natural hazards in the areas in which the proceeds of the grants or loans are to be used shall be evaluated and appropriate action shall be taken to mitigate such hazards, including safe land-use and construction practices...."¹⁶

Recognizing such problems in the late 1970s, FEMA undertook research and began to apply a variety of measures to reduce the flood loss poten-

tial of existing uses, particularly after disasters. In 1979, FEMA initiated a floodplain acquisition program pursuant to Section 1362 of the National Flood Insurance Act of 1978.¹⁷ Section 1362 provides FEMA with the authority to acquire flood-insured properties that have been severely damaged three or more times or "substantially damaged beyond repair," and where the state or community agrees to accept and manage the property after federal acquisition.

The 1980 program began with acquisition of 94 properties: eight in Scituate, Massachusetts; one in Strathmore, New Hampshire; five in Gulf Shores, Alabama; six in Clay County, Minnesota; 20 in San Bernardino, California; 34 in Arnold, Missouri; four in Phoenix, Arizona; and 16 in Cowlitz, Washington. During 1980, FEMA also funded the relocation of 67 structures in Montgomery County, Texas, through "constructive total loss" payments for structures that could not be repaired or rebuilt due to county nonconforming use provisions.

FEMA was not alone in its concern with existing uses. During 1979, the U.S. Water Resources Council carried out two postdisaster recovery studies: one on postdisaster response¹⁸ and another on floodplain acquisition.¹⁹ WRC also examined federal response in various postdisaster situations.

Based on these studies and on urging from OMB, WRC, and FEMA, federal agencies increased enforcement of the postdisaster hazard mitigation requirements of the 1974 Disaster Protection Act. SBA and other loans were denied for rebuilding in specific places at Lake Elsinore, California, and Soldiers Grove, Wisconsin. A variety of federal funding was provided to facilitate acquisition of lands and relocate structures in Soldiers Grove and in Gulf Shores, Alabama.

In July 1980, OMB directed 10 agencies involved in disaster response to work together to assess mitigation possibilities within 15 days of a

presidentially declared disaster in order to improve coordination of postdisaster response, with FEMA as the lead agency.²⁰ A mitigation handbook has been prepared to assist the teams in their evaluations.²¹

Other federal programs to reduce losses to existing uses include construction of flood control measures and flood warning systems described below as well as funding for state and local efforts.

Effective State and Local Programs

Some communities and states have adopted programs for existing uses although effective efforts are quite rare.

Moratoria on Rebuilding

A number of coastal and inland communities adopted moratoria on rebuilding after flood disasters until relocation plans, flood control measures, or comprehensive floodplain management plans could be prepared and implemented. The best example is Rapid City, South Dakota, where the city planning commission adopted a moratorium on repair and rebuilding in the 10-year floodplain after the flash flood of 1972 killed 238 and damaged or destroyed 824 structures. The South Dakota Supreme Court sustained this moratorium. There are other examples.

- Larimer County, Colorado, adopted a six-month moratorium on rebuilding after flash flooding in the Big Thompson Canyon in 1976 caused \$42 million in damage and took 136 lives.
- San Bernardino, California, adopted a moratorium preventing rebuilding in an area that was damaged by mud flows three times in January and February of 1979.
- Lake Elsinore, California, prevented rebuilding below an elevation of the 100-year flood plus five feet after a severe flood in 1978. Some of these damaged properties are now being acquired.
- Cowlitz County, Washington, adopted a moratorium on new development and rebuilding in the 500-year floodplain of the Cowlitz River and within the "mudline" of the Toutle River after severe floods and mud flows resulted from the Mount St. Helens eruption in 1980.

Upgraded Regulations

Some communities adopted more permanent, upgraded regulations for reconstruction and new development after a disaster. Heightened public awareness and information from the more detailed flood studies, which are typically undertaken after severe floods, made the upgraded regulations politically acceptable. Some typical examples follow.

- Del Norte County, California, adopted highly restrictive floodplain regulations for an area along the Klamath River, which had been flooded in 1927, 1953, 1955, and 1964. Flooding in 1964 destroyed the town of Klamath. These regulations prevented rebuilding and use of the land for permanent buildings. The California Supreme Court sustained the regulations.
- Clay County, Minnesota, prohibited rebuilding in the 100-year floodplain of River Oaks subdivision, which was severely inundated by the Red River twice in 1978.
- Scituate, Massachusetts, adopted a moratorium on rebuilding after a northeaster struck the New England coast on February 6 and 7, 1978. The storm destroyed or seriously damaged 700 structures. This moratorium was subsequently modified to permit rebuilding of structures pursuant to upgraded regulations requiring protection against waves to a height of 21 feet.
- Gulf Shores, Alabama, adopted a temporary moratorium on rebuilding after Hurricane Frederic damaged or destroyed 500 structures in September 1979. This moratorium was subsequently modified to permit rebuilding consistent with wave heights.

Regulations with Acquisition and Relocation

Several states and more than 100 communities acquired structures damaged by severe flooding. Arizona is relocating residents in 10 flood-prone communities, including Hollywood, Duncan, and Allenville, pursuant to a relocation program authorized by the Arizona legislature in 1978. This program includes exchange of public lands for private flood-prone lands and state financial aid for relocation. After the severe 1978 coastal storm, the Massachusetts legislature adopted a \$1 million bond issue to help fund local acquisition of floodplain lands.

Some public uses have also been relocated. In 1978, the Minnesota Department of Natural Resources began removal of severely flooded campsites in Whitewater State Park. The state used HUD Disaster Assistance and state park funds for the now completed project.

Some state statutes specifically authorize local acquisition and relocation of existing uses under certain circumstances. For example, North Carolina authorizes a local government "to acquire, by purchase, exchange, or condemnation, such existing artificial obstructions (in floodways) if deemed necessary...for the purpose of avoiding flood damages."²²

Most communities have acquired floodplain lands after a disaster or repeated floods under more general acquisition or redevelopment powers.²³ A combination of flood insurance payments and disaster assistance grants and loans has often been used to meet acquisition costs. Funding has usually been federal, although some acquisition, such as that in Baltimore County, has been funded by both bonds and general revenues. Building moratoria were typically adopted after the disaster to prevent rebuilding before acquisition. There are many examples of acquisition and relocation.

- Prairie du Chien, Wisconsin, is now acquiring 128 residential properties in a repeatedly flooded area along the Mississippi and relocating owners. Funding of \$4.5 million is being provided by a HUD Community Development Block Grant and by the Army Corps of Engineers.
- Soldiers Grove, Wisconsin, is in the process of relocating its entire business district after repeated flooding. The most severe flood occurred in 1978, causing \$52 million in damages. Funding from several federal, state, and local sources was used. A 190-acre new town site has been purchased and prepared for development to meet multiple objectives of energy conservation and flood loss reduction.
- Dallas, Texas, has acquired 180 properties in two damage-prone subdivisions with funds from bond issues, HUD open space and urban renewal grant programs, the Land and Water Conservation Fund, and other sources.
- Gulf Shores, Alabama, is combining regulations and acquisition for certain beachfront areas devastated by Hurricane Frederic.



National Park Service structure inundated and later destroyed by storm waves at Coast Guard Beach, Cape Cod, Massachusetts.

Photo source: Stephen Leatherman

The city is acquiring five properties with funding from Section 1362 of the National Flood Insurance Act at an estimated cost of slightly over \$1 million. Other properties are being acquired through the Land and Water Conservation Fund and through donation.

Many other communities have cleared structures from floodplain areas as part of urban renewal or open space programs. Denver, Colorado; Austin, Texas; and Pittsburgh, Pennsylvania are examples.

Flood Warning Systems

Flood warning systems to reduce losses to existing uses have been developed or are under development by many communities with the help of the National Weather Service (NWS).²⁴ The NWS has in effect a flood watch and flood warning system for all coastal and inland waters.

Some communities with flash flood problems have developed more specific warning systems. For instance, Gatlinburg, Tennessee, has developed a specific, supplemental warning system. The West Prong of the Pigeon River, which is subject to severe flash flooding, bisects much of downtown Gatlinburg. Lying at the entrance to Smoky Mountain National Park, the town has many hotels, motels, and restaurants in the flash flood area. A storm in the Smoky Mountains, 20 miles from downtown Gatlinburg, could send 10 feet of water into the town only 15 minutes after the first warning.

The Tennessee Valley Authority (TVA) and the town first studied structural solutions to the flood problem, but found none practical. Regulations were adopted to reduce losses to new uses. For existing uses, a sophisticated flood warning system and evacuation plan were later developed in cooperation with NWS. This system involves automatic rain and river gages, a computer model of the watershed, automatic data processing, and automatic alarms. Both TVA and the town funded the system.

A flash flood warning system combined with regulations has been adopted by Brattleboro, Vermont, which also has severe flash flood problems. A major nursing home is located in one flash flood area along Whetstone Creek. With help from NWS and SCS, the town has implemented a computerized warning system similar to that for Gatlinburg.

Other warning systems are found in Lycoming County, Pennsylvania; Keene, New Hampshire; and Four Mile Run in Alexandria, Virginia.

Regulations and Flood Control Measures

Dikes, levees, detention ponds, small dams, and stream channelization projects have been combined with regulations both before and after floods. Federal agencies have often assisted in these efforts.

- Littleton, Colorado, combined flood control measures, acquisition, and regulations to reduce flood losses after a flash flood in 1965 took 13 lives and caused \$399 million in damages. The Corps of Engineers constructed an \$86 million earthen dam to lessen flood damages in Littleton and downstream communities.
- San Bernardino, California, combined regulation of mud flow areas with acquisition and relocation of selected properties, the construction of mud flow retention walls, and the seeding of upstream canyon walls to reduce mud flows.
- Scottsdale, Arizona, near Phoenix, combined regulations with acquisition and limited flood control measures in a \$30 million bond project for 4.5 miles of Indian Bend Wash. A dike was constructed to protect the flood fringe area.
- Riverside County, California, combined floodplain regulations with various types of levee and channelization projects to reduce stream, alluvial fan, and sheet flow flood problems. Flood control projects have been constructed primarily by the Riverside County Watershed Conservation and Flood Control District and by the Coachella County Valley Water District, with funding from bond issues.
- Palatine, Illinois, combined floodplain regulations with a program to maintain existing floodway channels, build five floodwater retention structures and one multipurpose flood prevention and recreation facility, improve the flow carrying ability of 1.8 miles of stream channel, and purchase 261 acres of floodplain.
- Rockville, Maryland, combined regulations requiring subdividers to provide onsite storage of waters with a local government program to construct onsite stormwater detention ponds.

Twenty-four of these ponds have been constructed with 18 more planned or under construction.

Despite their advantages, once flood control measures are proposed or constructed at public expense for one area of a community, local officials have often found it difficult to gain landowner support for nonstructural measures that require landowners to bear the costs of flood protection in other areas. Landowners may also resist regulation in areas partially protected (e.g., to a 25-year flood elevation) by dikes or dams.

Evacuation Maps and Plans

The National Oceanic and Atmospheric Administration (NOAA), with state and local help, has prepared flood evacuation maps for much of the East Coast. The maps show evacuation routes, safe sites, and various depths of anticipated flooding. They also show historic flood elevations for particular storms. Some communities have prepared more specific flood evacuation plans with help from the Corps, NWS, NOAA or FEMA. These assess flood hazards, identify evacuation routes and measures, and suggest flood preparedness measures. Plans have been prepared or are under preparation by Lee, Collier, and Monroe Counties, Florida; Baytown and Galveston, Texas; and other areas.

CHAPTER III

Footnotes

1. Sheaffer and Roland, Inc. (1978), estimated that 7.9 percent of the 57.3 million occupied housing units in the nation were in special flood hazard areas for a total of 4.5 million housing units. This study also estimated that 325,000 nonresidential units were located in flood hazard areas.

The report concluded that:

In summary, experience to date indicates that the current approach to correcting nonconforming uses through zoning mechanisms is not effective. Nonconforming uses, particularly residences, are allowed to continue even when they are substantially damaged unless they are purchased (p. 10).

Surveys of state and local programs conducted as part of the present study (see Appendix A and Appendix B) supported this conclusion.

2. Claim data from the National Flood Insurance Program.
3. *Id.*
4. See Platt (1979).
5. See footnote 47, Chapter I.
6. 41 Fed. Reg. 46,963 and 46,964 (1976).
7. *Id.*
8. See, for example, Miller (1980).
9. Zoning statutes specifically exempt nonconforming uses from municipal regulation (cities and villages) in at least 14 states, from county regulation in 15 states, and town or township regulation in 12 states. For a list of these states and more detailed references, see Strauss and Kusler (1976).
10. Zoning enabling statutes in 14 states specifically authorize the regulation and termination of nonconforming uses. Included are the enabling acts for municipalities in seven states, counties in 10 states, and towns or townships in five states. The enabling acts of the remaining states are silent as to the treatment of nonconforming uses.
11. Mo. Ann. Stat. § 64.620 (Vernon 1966).
12. See Minn. Stat. Ann., § 394.36 (West Supp. 1982) which provides in part:

Subdivision 2.--The board may by ordinance as herein provided prescribe such regulations not contrary to law as it deems desirable or necessary to regulate and control, or

reduce the number or extent of or the gradual elimination of nonconforming uses and occupancies.

13. In many instances, courts also have supported regulations which require the short-term abatement or alteration of nonconforming uses which are nuisance-like or threaten public safety. See Anderson (1968), sections 6.65-6.71 at 446-471 and cases cited therein. See Hadacheck v. Sebastian, 239 U.S. 392 (1915); Reinman v. Little Rock, 237 U.S. 171 (1915).
14. See footnote 6, Chapter II.
15. See Tressler (1979).
16. Section 406 of the Flood Disaster Relief Act of 1974, P.L. 93-288 (codified at 42 U.S.C.A. § 5131(c) (d) (West 1977)).
17. Section 1362 of the National Flood Insurance Act of 1974, P.L. 90-44 (codified at 42 U.S.C.A. §§ 4001-4128 (West 1977)). See also footnote 23.
18. Platt (1979).
19. Kusler (1979b).
20. Memorandum, Office of Management and Budget, July 10, 1980. Guidelines developed by FEMA and directed to 10 agencies provide, in part, the following post-disaster planning process:

To accomplish the objectives of the post-flood recovery efforts, . . . departments and agencies should develop a common policy and enter into an interagency agreement that provides for Federal leadership and participation in interagency, interdisciplinary and intergovernmental hazard mitigation teams. The teams shall be led by a designated FEMA official in cooperation with affected State and local governments. At the time of presidentially-declared disasters, the teams will:

- assess the extent of damage;
- identify riverine floodway and coastal high hazard zones, in which Federal investment to repair or replace structures and facilities should be avoided and the relocation of people and structures out of these areas encouraged;
- identify floodplain fringe areas in which Federal assistance should seek to mitigate hazards through the flood-proofing of structures, forecasting-warning-evacuation plans, floodplain regulations, and development and redevelopment policies;
- prepare expeditiously--normally within 15 days--a hazard mitigation report recommending specific recovery actions to be taken by each Federal agency and each non-Federal level of government; Federal agencies shall conform their recovery actions to the recommendations of the report to the fullest extent practicable.

21. Federal Emergency Management Agency (1981).
22. N.C. Gen. Stat. § 143-215.55 (1978).
23. See Ralph M. Field Associates (1981); Federal Emergency Management Agency (1981); and other references on floodplain acquisition in the bibliography of this report.
24. See Owen (1977), and Wright *et al.* (1976) who recommends the following elements in a neighborhood watershed flash flood warning system:
 1. Neighborhood Boundary Map
 2. Neighborhood Coordinator
 3. Watershed Rainfall Observation Stations
 4. Neighborhood Alert System
 - a. Neighborhood Warning Signal
 - b. Neighborhood Telephone Alert System
 - c. Mass Media Alert System
 5. Stream and Road Patrols
 6. Neighborhood Damage Reduction
 7. Assistance from Larger Units of Government
 8. Record Keeping
 9. Training Program

CHAPTER IV

RESOURCE PROTECTION AND HAZARD MITIGATION

Overview

In the last decade, Congress, the states, and local governments have adopted a variety of independent resource protection and management programs that apply in part to floodplains.¹ These programs often contain hazard mitigation standards for new uses or indirectly reduce flood losses by restricting the types, locations, and densities of uses and by protecting flood conveyance and storage. They also protect natural vegetation and control erosion.

Conversely, many floodplain management programs have been adopted or amended to include resource protection and management standards to meet multipurpose community goals such as protection of prime agricultural areas and wetlands. Such provisions have been adopted to promote the wise use of floodplains, as determined at state and local levels. This concern with floodplain resource values is reflected in the NFIP standards and in the Floodplain Management and Wetlands Protection Executive Orders.

Independent resource protection and management programs that apply wholly or in part to floodplain areas include wetland, prime agricultural land, and mineral resource protection programs; coastal zone and shoreland management programs; and "critical area" programs. Many programs have been adopted at the state level as state or cooperative state/local planning and management efforts.

Two types of state and local resource management and floodplain management standards have been applied to protect and conserve natural values. The first--tight control or prohibition of structural development in selected areas--has been applied to highly hazardous or sensitive floodways, wetlands, and habitats for rare and endangered species.

TABLE 5

RESOURCE PROTECTION BENEFITS

Regulations, acquisition and other techniques to maintain all or portions of floodplain areas in an open condition can serve the following objectives:

Protect Water Resource Values

Natural Moderation of Floods (Avoid Costs of Flood Control Works)

- reduce flood velocities
- reduce flood peaks
- reduce wind and wave impacts

Water Quality Maintenance (Avoid Costs of Waste Water Treatment)

- remove nitrogen, phosphorous, toxics, litter from runoff before reaching rivers, lakes and streams
- remove pathogens from runoff
- moderate temperature of water
- reduce downstream siltation

Groundwater Recharge (Reduce Costs of Water Supply)

- increase groundwater infiltration for human use and low flow during dry periods
- prevent land subsidence

Maintain Living Resource Values

Protect Flora

- maintain the high biological productivity of floodplain and wetland flora important to animals and people
- maintain the productivity of natural forests and the supply of timber products
- maintain natural crops such as salt marsh hay, blueberries, cranberries

Protect Fauna

- create and enhance wildlife habitats for breeding and feeding of water fowl
- provide migratory flyways for water fowl
- protect habitat of rare and endangered species
- maintain breeding and feeding grounds of fish, shellfish

Maintain Cultural Resource Values

Protect Open Space

- absorb noise
- clean air
- moderate temperatures
- reduce erosion
- preserve historical and archaeological sites

TABLE 5 (continued)

Protect Natural Beauty

- provide variety in the urban pattern
- provide natural greenbelt and forested areas of natural beauty

Protect Scientific Study and Outdoor Education Areas

- serve as an ecological "experiment station"
- facilitate study of the unique wildlife occurring at the interface of land and water
- serve as a classroom for how human and natural systems are linked

Protect Recreation Areas

- provide opportunities for water sports (swimming, boating)
- provide areas for hunting, fishing, and wildlife preservation
- provide wilderness experience areas (in some cases)
- provide areas for hiking, camping, picnicking, bird watching

Maintain Cultivated Resource Values

Protect Agricultural Lands

- renew soil through sediment deposition (periodic flooding) and replenish nutrients in soil for higher productivity
- reduce the need for commercial fertilizer additives
- in some cases, provide uniquely suitable soil for specialty crops

Protect Aquaculture

- provide areas for cultivation of fish, shellfish

Protect Silviculture

- create and preserve valued species that have adapted to naturally moist conditions, especially bottomland hardwoods
- enhance productivity of forest resources and provide opportunity for sound commercial management

This type of regulation is best in small areas where upland sites are available for development.

The second--general performance standards--requires that activities incorporate environmental mitigation measures to reduce project impacts. Mitigation measures of the sort listed in Table 6 are required for permitted uses. Mitigation standards are contained in zoning and subdivision control ordinances and "special permit," upgrading, floodplain, wetland, and regional impact regulations.² Environmental impact statements are often required for major projects.

Both resource protection and floodplain management with resource protection provisions protect the nine principal natural resource functions discussed below.

Natural Resource Values

Flooding contributes to the maintenance of special natural resources. Flowing waters shape lands, thereby creating optimum flood conveyance configurations. Flood waters deposit rich soils particularly suited for agriculture. Storm waves create beaches and bars attractive for swimming and other recreation. Fast-moving flood flows deposit sand and gravel needed for roads and industry. Rains and periodic flooding recharge groundwater supplies. High groundwater levels and periodic flooding give rise to "wetland" vegetation and wildlife that contribute to food production, fish spawning, pollution control, bird watching, hunting, fishing, and aesthetic values.

Most floodplain natural values such as forestry, wildlife, and pollution control are adjusted to and may depend upon periodic flooding. In contrast, unprotected development at the same sites is subject to flood damage. Protection of development through floodproofing, dikes, levees, channelization, and similar measures is, in the long run, prone

TABLE 6

TYPICAL MITIGATION APPROACHES

1. Minimize impact on natural values by limiting floodplain occupancy to compatible uses.
2. Avoid locating fill and structures within critical wetlands, dunes, beaches, and scientific areas.
3. Reduce impacts on sensitive areas by elevating structures on pilings or other open works.
4. Avoid sensitive areas by routing access roads, sewers, and water supply systems around them.
5. Avoid vegetation removal on dunes, in wetlands, and along stream banks by means of building setbacks and limitations on cutting and grading.
6. Replant wetland and other vegetation where destruction of vegetation cannot be avoided.
7. Protect erosion-prone areas through rip-rap or other measures.
8. Avoid removal of sand, gravel, and other materials from beaches and dunes.
9. Avoid use of off-road vehicles where they may destroy dune and wetland vegetation.
10. Protect fish populations by constructing fish pools in channelization projects and installing fish ladders at dams.

11. Compensate for destroyed areas by constructing new wetlands and other wildlife areas by diking, land acquisition, or other means.
12. Manage game to enhance and reestablish species.
13. Reconstruct disturbed or destroyed natural dunes by planting vegetation, beach nourishment, and other techniques.
14. Control runoff from construction sites by using plastic sheets and similar measures.
15. Reduce sedimentation by constructing detention ponds.
16. Provide sufficient flows for downstream fish and wildlife and periodically flush wetlands by managing dam operations.
17. Limit development densities (e.g., require large lot sizes).
18. Protect sensitive and hazardous areas by clustering development on upland sites.
19. Permit adequate groundwater infiltration by limiting the allowable amount of impermeable surfaces.
20. Avoid disposal of wastes, litter, and debris in wetlands and floodplains.
21. Protect natural vegetation and water quality and reduce erosion by fencing wetlands and floodplains.

to failure because it opposes the natural processes of flow, erosion, scour, sedimentation, and stream and beach migration.

Not all floodplains are characterized by the same natural values, nor have natural resource protection and floodplain management in the 1970s given equal weight to all values.

Flood Conveyance

Flood conveyance is a valuable function of river channels and adjacent overbank areas. These areas are shaped by the erosion and deposition accompanying large floods. Fill, structures, and other development in such natural floodways cumulatively increase flood heights and velocities, causing not only increased flood damages on adjacent and upstream lands but also downstream erosion. Plant and animal life in these areas has adapted to and may depend upon periodic flooding.

Protection of flood conveyance was a common objective of shoreland, wild and scenic river, wetland regulatory, and floodplain management programs in the 1970s. Many of these programs were designed to protect the entire natural or "no rise" floodway. The programs assume no permitted increases in flood heights and are more inclusive than the NFIP regulatory floodway.

Flood Storage

Except in areas characterized by steep terrain and bluffs, most riverine floodplains provide temporary flood storage, thereby lowering downstream flood peaks. One acre of floodplain can hold more than 330,000 gallons of water if flooded to a depth of one foot.

Flood (also termed valley) storage is particularly important in urbanizing areas where even small floods resulting from a five- or a 10-year storm can cause severe flood damage. The flood storage effectiveness of a particular floodplain area depends on its size and hydrologic



A wetland reestablished on dredge spoil as a mitigation measure.

Photo by John Clark.

character, flooding characteristics, the distribution of streams or rivers in the watershed, vegetation and ground cover, and the location of development.

Protection of flood storage was an objective of most inland state and local wetland programs and some shoreland zoning and wild and scenic river programs. Some localities also adopted floodplain or stormwater management regulations to protect storage. NFIP standards do not directly address storage, although floodway restrictions provide some protection. For this reason many wetland and comprehensive flood hazard management policymakers consider the NFIP standards to be inadequate. In order to compensate for this problem, some state and local floodplain regulations use a natural floodway or allow less than the one-foot rise permitted by the NFIP standards.

The federal government has protected some natural storage areas. For example, the Corps of Engineers, after studying the Charles River near Boston in 1965, reversed an earlier recommendation for a flood control structure and instead recommended protection of 17 parcels, constituting 8,500 acres, which function as natural storage areas. The Corps has now acquired much of this land. State and local regulations will protect other storage areas along the Charles.

Wave Reduction

Beaches, bars, dunes, and wetlands act as natural barriers that dissipate coastal waves and protect backlying areas from flooding and erosion. Along the coast, waves may cause severe damage for a distance of 300 to 1,000 feet inland, depending on topography, vegetation, and manmade or natural barriers. Coastal islands are vulnerable to extensive impacts from storm waves.

Natural barriers form several lines of defense against waves and erosion. Offshore and nearshore bars are the first line of defense. They absorb much of a wave's energy, causing it to "break" and weaken even though it may travel some distance inland. Dredging beaches or bars to replenish dunes may increase wave damage by increasing wave heights. Most coastal states now control dredging, sand removal or other alteration of beaches through floodplain, wetland, and beach protection; shore erosion control; or coastal zone management. Generally, floodplain regulations also prohibit structures below the mean high water line. Federal 404 or Section 10 permits are required for most dredging activities.

Dunes lying behind the beach are the second line of defense against storm waves, although a severe storm may destroy the dunes.³ In addition to acting as buffers to waves and erosion, they also partially protect against hurricane winds, which may exceed 150 miles per hour. Dune areas are also important for recreation and contain unique plant and animal species. Florida has adopted a beach setback line, designed in part to protect dune areas.⁴ North Carolina has adopted dune protection regulations as part of its coastal zone management program.⁵ Many local communities have adopted dune protection ordinances, particularly in Massachusetts, New York, North Carolina, and Rhode Island. NFIP standards require protection for dunes where it is shown that any proposed alteration could cause flood damage.

Vegetated coastal wetlands are a third line of defense in estuaries and behind barrier islands.⁶ Growth of wetland vegetation is rare in open coast areas. Vegetated wetlands form in backlying areas which are subject only to infrequent storms such as the 100-year storm. When such events occur, wetland vegetation causes waves to dampen and break, dissipating much of their energy. Root systems of Atlantic coastal vegeta-

tion, such as those of Spartina alterniflora, bind and protect the soil against erosion.

Mangrove forests found in Florida and, to a lesser extent, Louisiana, are particularly important wave buffers.⁷ Red and black mangroves grow to a height of 20 to 35 feet for a distance of 1 to 10 miles inland from the coast. They take root in standing water and have complicated root and above-ground systems. During hurricanes they substantially reduce the force of storm waves and may actually build up the land by trapping sediments. A study of how mangroves retard erosion revealed that when Hurricane Hattie struck the Caribbean in 1961, with 200-mile-per-hour winds and 15-foot tides, islands covered with natural vegetation suffered little permanent damage and in some instances actually accumulated new material from the storm.⁸ In contrast, islands cleared of vegetation were severely eroded.

NFIP standards require protection of mangroves within defined velocity zones if it can be shown that any proposed alteration would increase potential flood damage. However, the standards disregard other forms of vegetation that may have the same potential.⁹

Efforts are being made to protect coastal wetlands and mangroves through wetland protection, coastal zone management, and pollution control programs. The Corps generally denies Section 404 permits for alteration of mangroves and other coastal wetlands. Florida is enforcing mangrove protection measures through its setback requirements, pollution permit systems, and similar measures. Virtually all coastal states have adopted coastal wetland protection measures.

Inland wetlands also reduce wave and erosion damages along lakes and rivers and provide a buffer to pollution associated with flooding. Massachusetts, Rhode Island, and other states regulate activities in



The extensive root structure and flexible stems of mangroves resist erosion and storm waves.

Photo by Jon Kusler

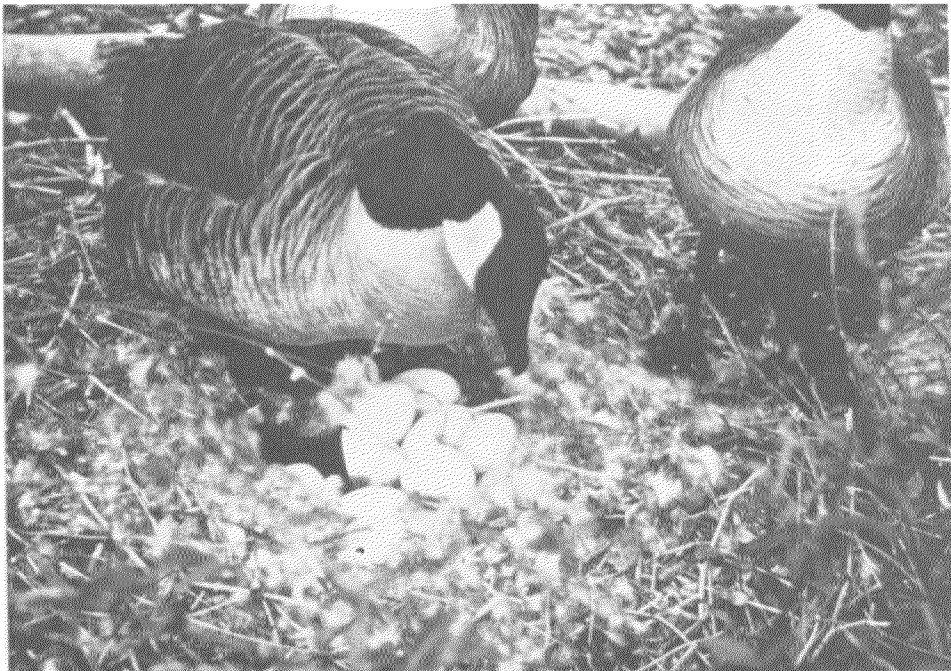
inland wetlands. Many local communities, particularly in states like Florida, Massachusetts, and Virginia, have adopted wetland protection ordinances.

Waterfowl and Wildlife

Due to the abundance of water and vegetation, floodplains provide habitat for much of the nation's wildlife. Wetlands along the Gulf Coast provide nesting and feeding grounds for many species of waterfowl. Mississippi River floodplains are major duck and geese resting and feeding grounds during fall and spring migrations. The prairie potholes of the Midwest are nesting areas for about 50% of the nation's ducks. The vegetated floodplain corridors along western rivers and streams are particularly important to birds and fish. Many animal species such as raccoons, deer, moose, turtles, and salamanders spend a portion of their lives in floodplains. Inland floodplains normally accessible to open water along lakes and streams provide nursery habitat for fish such as northern pike and walleye. Florida mangroves provide protection for shrimp and for the fingerlings of commercial fish such as mullet, snook, and snapper. The value of the nation's nearshore and continental shelf fishing annually exceeds one-half million dollars. Nine out of 10 commercially important fish species either pass their entire lives in estuaries or require estuaries as nursing grounds.

Over 35% of the nation's rare and endangered species live all or a portion of their time in wetland areas.¹⁰ Such species include the Everglade kite, the whooping crane, the Sandhill crane, the bald eagle, the American crocodile, and the Florida panther.

Most state coastal and inland wetland regulation and acquisition programs and the Federal 404 permit program are designed, in part, to protect duck nesting and fish spawning grounds. However, state and federal floodplain regulations rarely emphasize wildlife protection as



Canadian geese nesting in wetland area.

Photo by Dave Davis.

an objective, although they may incidentally achieve this result by limiting alteration of habitat.

Pollution Control

Floodplains buffer rivers, streams, lakes, and estuarine waters from upland sources of pollution. Floodplain vegetation reduces the velocity of sediment-laden flood water, and results in deposition on overbank areas rather than in lakes, reservoirs, and streams. Vegetation also traps sediment and organic particles.

Nutrients, chemicals, and other materials migrating through groundwater or surface water systems are filtered by floodplain soils or degraded by floodplain bacteria. For example, studies of heavily polluted waters flowing through Tinicum Marsh in Pennsylvania revealed significant reductions in biological oxygen demand, phosphorus, and nitrogen within three to five hours.¹¹ A variety of studies are now under way to investigate the use of wetlands and floodplains for tertiary treatment of domestic and industrial wastes and stormwater runoff.¹²

Federal, state, and local wetland, shoreland zoning, coastal zone management, and wild and scenic river programs are designed, in part, to prevent pollution by providing setbacks and maintaining vegetation. Federal 404 permits are denied for areas that may serve pollution control functions. Although pollution control is often a stated objective of floodplain regulations, regulation of shoreland vegetation removal and control of subtle sources of pollution is rare.

Natural Crops, Agriculture, Forestry

Floodplains produce a variety of natural crops that do not depend on fertilizer,¹³ for example, blueberries, cranberries, and wild rice. Coastal wetlands have historically been harvested for salt marsh hay.



Salt marsh hay, Wellfleet, Massachusetts.

Photo by Jon Kusler.

Coastal aquaculture, including propagation of oysters, is carried on in Long Island and the Chesapeake Bay. Research during the 1970s showed that wetland plants could produce biomass suitable for fuel while removing unwanted nutrients from waters.¹⁴ Cattails can also produce alcohol as a supplement to fossil fuels. Some wetland and coastal zone management programs are designed in part to protect natural crops. Floodplain regulatory programs rarely address this issue.

Inland floodplains along larger rivers are often prime agricultural lands because of their flat terrain, abundant water supplies, and rich alluvial soils which are periodically replenished by flooding. Measures to preserve prime agricultural lands and shape urban growth have been taken in California, Hawaii, Maryland, Massachusetts, New Jersey, and Oregon. Glastonbury, Connecticut; Northampton, Massachusetts; and Walworth County, Wisconsin, have adopted prime agricultural zoning for floodplain areas.

Inland floodplains are often sources of timber. Principal commercial species are cypress, gum, loblolly, tamarack, maple, and spruce. Some wetland and forest protection programs regulate excessive cutting in forest areas.

Groundwater Supply and Recharge

Municipal and private water supply wells are often located in floodplain alluvial deposits. Floodplains and wetlands are an increasingly important source for water supplies. Floodplains are often groundwater recharge areas in the arid west.

Some independent wetland and aquifer recharge protection regulations have been adopted, particularly in Massachusetts and the West. However, floodplain regulations rarely cover groundwater supply and recharge, although they may incidentally serve to protect recharge by limiting impermeable surfaces.

Recreation, Cultural, Historic Values

In many areas of the country, states and localities have acquired floodplains to serve as fishing, hunting, bird watching, picnicking, hiking, jogging, swimming, and boating areas. Coastal and inland floodplains provide fishing sites for many of the 20 million Americans who fish for recreation. Coastal and inland riverine floodplains are principal duck and geese hunting areas. Millions now birdwatch in wetlands and floodplains. A 1978 study of 17 major cities, by the Heritage Conservation and Recreation Service and the National Park Service, revealed that floodplains were often the prime remaining park and recreation sites in major urban areas.¹⁵

Floodplains also have cultural and historic significance. Many were used by native Americans and the first settlers as fishing and agricultural areas because fish and shellfish, a water supply, and water transport were available. Cities grew up along the major rivers and in coastal bays. Boston, Austin, and Tulsa, to name a few, have focused their major urban renewal and historical preservation and restoration projects on waterfront areas.

Floodplain regulations protect recreation and cultural values by limiting development densities and encouraging such private recreational uses as golf courses, picnic areas, and playing fields.

Sand and Gravel Deposits

Swiftly flowing waters often deposit sand and gravel in inland floodplains. Colorado has adopted mineral protection legislation which applies in part to floodplains.¹⁶ Some communities have also adopted exclusive mineral protection zones to control mining of sand and gravel. Floodplain regulations rarely protect mineral resources as a stated objective although they may incidentally protect deposits from incompatible development by restricting the types and densities of development.

Resource Management Programs

Four principal types of resource management programs were applied to floodplains as well as other lands during the 1970s: wetland, coastal zone management, shoreland, and "miscellaneous" programs such as wild and scenic river and prime agricultural land protection.

Wetland Protection Programs

Wetland regulatory programs are most directly applicable to floodplain management. Wetlands are typically the "wettest" and most hazardous areas of floodplains, and lie within the one-year or two-year floodplain. Wetland areas are characterized by saturated, organic soils (caused by high groundwater, tides, or periodic flooding), and by plant species capable of growing in semi-aquatic or water-rich conditions.¹⁷ Coastal marshes are flooded to elevations of six to 15 feet by the 100-year flood and may be subject to high velocity waves. Inland wetlands along rivers often lie within floodway areas. Wetlands along lakes and isolated wetlands are subject to periodic increases in ground or surface water level which cause flooding of nearby structures, although they may not lie within traditionally defined floodplains.

The placement of material in most wetlands requires a federal permit from the Army Corps of Engineers pursuant to Section 404 of the Water Pollution Control Amendment of 1972, the Clean Water Act of 1977,¹⁸ and Section 10 of the Rivers and Harbors Act of 1899.¹⁹ Flood conveyance, flood storage, and flood damage potential are considered in processing permits.

All coastal states have either adopted separate coastal wetland protection programs or have incorporated wetland regulations in coastal zone management or shoreland management programs.²⁰ Hazard mitigation is often an objective. Most coastal states have mapped wetlands at



Organic soils found in many wetlands compress under pressure, causing structural damage to buildings and roads. They are also unsuitable for onsite sewage disposal.

Photo by Richard Newton

scales that range from 1"=200' to 1"=1000'. Permits are required for fill, dredging, and other uses that may destroy or damage wetland areas. Maryland, Massachusetts, New Jersey, and New York have particularly effective programs.

At least seven states have adopted inland wetland protection regulatory statutes.²¹ Massachusetts and Rhode Island have amended statutory wetland definitions to require permits for fill and structures in the 100-year floodplain. Aerial photos are usually used for mapping wetlands, although Connecticut uses soils maps. Rhode Island and, to a lesser extent, New Hampshire and Florida require state permits. In Connecticut, Michigan, New York, Virginia, and Wisconsin, local governments issue permits if they have adopted regulations consistent with state standards.

Several thousand local governments have combined wetland protection and floodplain management ordinances. Typically these establish tight protection standards (no fill or dredging) for wetland and floodway areas. Flood protection through elevation on fill or floodproofing is required for structures in outlying areas. In some instances, communities (e.g., Orono, Minnesota; Glastonbury, Connecticut) control development throughout the 100-year or even 500-year floodplain with the intention of protecting wetland areas.

Coastal Zone Management Programs

Congress adopted a national Coastal Zone Management Act in 1972.²² During the 1970s, all coastal and Great Lakes states provided some regulatory control over coastal zone uses, often through a combination of statutes on beach, "navigable water," and wetland protection.²³ Regulations range from minimal beach setbacks (e.g., Florida and Hawaii) and wetland regulations in 15 states, to comprehensive coastal zone acts (e.g., California, North Carolina). Some wetland and broader programs involve direct state control. However, the Maine, North Carolina,

Minnesota, Washington, and Wisconsin programs rely primarily on local control within a framework of state standards.

State statutes define regulated coastal zone areas to include lands within specified distances of the water.²⁴ Coastal zone boundaries include a narrow, 200-foot shoreline area in Washington; 250 feet in Maine; 1,000 feet in Wisconsin, Minnesota, and Michigan; 1,000 yards in California; and all of the coastal counties in North Carolina. The Delaware and New Jersey coastal zone acts, directed toward industrial development, define coastal zone boundaries by particular roads.

Implementation of coastal zone programs usually involves mapping and more specific regulation of discrete coastal subzones such as wetlands, erosion areas, flood areas, and recreation areas. The Coastal Zone Management Act of 1972 and the basic enabling acts of several states require the identification of subzones of "particular concern," including many types of resource areas.

Some programs emphasize management of flood and erosion areas. Massachusetts has adopted an executive order prohibiting state investment in barrier beaches and it has a state building code incorporating wave heights for coastal hazard areas. It has also mapped erosion hazard areas and barrier islands and provided technical assistance and grants to aid communities.

The Rhode Island Coastal Commission regulates dunes, beaches, and wetlands. With funding from the state coastal zone management program, the University of Rhode Island provides erosion and flood maps and technical assistance to local coastal management programs. Many local governments such as South Kingston and Warwick have adopted flood hazard zoning.

The North Carolina coastal zone program also stresses flood and erosion hazards. It requires local governments to regulate flood and erosion areas of "critical concern." Erosion problems are emphasized in



Dune protection measures in Lewes, Delaware.

Photo by Jon Kusler.

the Michigan shoreline program, which has identified a 10-year erosion setback. The California coastal zone management program has also identified erosion and flood areas.

Shoreland Zoning Programs

Six states have adopted special legislation for the protection and management of shoreline areas:²⁵ Maine, Michigan, Minnesota, Vermont, Washington, and Wisconsin. Legislation adopted in Maine and Washington applies both to inland and ocean shorelines; legislation in Wisconsin and Minnesota applies to the Great Lakes as well as to other lake and stream areas. Statutes in all six states establish standards for local government regulation of shoreland areas. Several thousand communities and counties have adopted regulations pursuant to these statutes. Many contain flood hazard provisions.

States and communities have used two methods to classify shoreland areas more specifically. The first, applied in Wisconsin, identifies individual subzones such as wetlands around lakes. The second, used in Minnesota, classifies lakes in their entirety for "natural environment," "recreational development," and other uses. Varying shoreland use standards for each class apply to lot size, water frontage, building setbacks, and other matters. Both types of classification apply to floodplain maps and standards to supplement the more general classifications.

All shoreland regulatory programs authorize state standard-setting for local zoning, subdivision controls and, in some cases, sanitary codes. The six states have adopted standards to serve multiple goals: prevention of pollution, prevention of increased flood hazards; minimization of land use conflicts; protection of wetlands; protection of wildlife and scenic beauty; and protection and enhancement of recreation values. In general, programs permit low-density residential and recreational uses in

shoreland areas. However, they tightly restrict development and fills in wetland areas and flood hazard areas.

Michigan, Minnesota, and Wisconsin emphasize flood and erosion hazards in their shoreline programs. In Washington, the Department of Ecology has developed a detailed coastal zone atlas, including maps of flood and erosion hazard areas.

Other Resource Management Programs

Flood hazard mitigation has been achieved to a greater or lesser extent through a variety of other resource management programs. For example, Michigan communities have adopted combined floodplain and wild and scenic river regulations pursuant to a state "natural rivers" statute.²⁶ This statute directs the Department of Natural Resources to prepare river corridor plans for "wilderness," "wild scenic," and "country scenic" rivers. Plans are to manage rivers for "floodplain" and other natural values. Local governments are to adopt regulations consistent with state plans. Regulations apply to a 400-foot corridor on both sides of designated rivers. The state will directly regulate this area if local authorities do not. Michigan has prepared plans for 10 rivers and 1,100 miles of river corridor. Wild and scenic river programs have also been adopted in California, Oregon, New York, and other states.

Some communities have also adopted agricultural zoning for floodplains. Flood hazard mitigation is an incidental benefit of "prime agricultural land zoning," which excludes or restricts the density of non-agricultural structures.²⁷ For example, Northampton, Massachusetts, has placed approximately 1,500 acres of floodplain along the Connecticut River in an exclusive agricultural use district. Glastonbury, Connecticut, has zoned approximately 800 acres along the Connecticut River for agricultural use.

"Riparian" habitat protection programs can also be used to mitigate flood hazards.²⁸ California communities protect "riparian cover" or habitat along watercourses to reduce bank erosion, increase groundwater infiltration, and provide wildlife habitats. A 1974 ordinance adopted by Napa County, California, protects riparian cover from planting or cutting within specified distances of streams. Other California counties with riparian habitat protection ordinances are Shasta, Santa Cruz, and Sacramento.

Conflicts and Problems

Although resource protection and flood hazard mitigation standards are usually compatible, conflicts have arisen.²⁹ Problems are due partly to differences in enabling legislation and program goals. Flood hazard reduction programs have narrowly focused on protection of individual structures from flooding, and on protection against the aggravation of the existing hazard by new development in floodways. In contrast, resource management has a broader goal to protect resource areas or manage their use. For example, floodplain regulatory statutes usually permit fill in outer fringe areas. In contrast, wetland regulatory statutes, which are designed to serve broader wildlife protection and recreation goals, prohibit fill.

The differing philosophies of program managers also lead to conflicts. Floodplain engineers and building inspectors often take a narrow flood hazard reduction approach; community planners and conservation program directors often take an overall resource protection approach. Engineers view flood hazards as "a problem to be solved or avoided." Conservationists see natural values as an asset to be protected, managed, or restored.

Because engineers are often unfamiliar with natural values evaluation, they fear that environmental objectives will weaken floodplain

regulatory programs. On the other hand, botanists and others responsible for wetland protection often do not understand engineering. They tend to underemphasize natural hazards because they believe a hazard focus reduces the acceptability of their efforts.

Other problems in coordinating or integrating programs are lack of simple and inexpensive procedures to evaluate values and hazards, of expertise in specific programs, and of resource maps showing the boundary locations of wetlands, prime agricultural lands, and other resource areas. Conflicts in policy appear in all levels of government but are often most severe at the federal level.

Coordinating Hazard Mitigation and Resource Management

Several measures could reduce conflicts and encourage coordination or integration of hazard mitigation and resource management.

- Local governments should map or inventory wetlands, prime agricultural lands, sand and gravel deposits, habitat for endangered species, and other resources as part of floodplain management or broader land use planning.
- Local and state floodplain management should fully consider resource values in planning and managing floodplains. New development should be guided away from floodplains (not just floodways) having special values.
- Local, state, and federal agencies should widely disseminate resource protection and flood hazard boundary maps and other informational materials.
- Local, state, and federal agencies should more thoroughly cross-reference or integrate floodplain regulations and broader resource protection regulations. For example, wetland protection standards can be incorporated into flood restrictions to prohibit fill and structures in wetland areas. Mitigation of development impact should be required if activities are permitted in wetlands. Similarly, flood standards could be placed in wetland regulations.
- Federal agencies and states should provide resource managers with basic training in flood hazard assessment. Similarly, basic training in assessment and protection of broader resource values should be provided floodplain management staff. A simple guidebook should be developed for evaluating floodplain natural values.

- NFIP standards protecting coastal dunes and mangroves should be clarified and more effectively enforced. NFIP regulations could also be amended to require broader protection of wetlands that are important in reducing flood and erosion damage. Upgraded hazard mitigation standards would also help protect critical resource areas. For example, the incorporation of wave heights and erosion standards in coastal flood hazard standards would increase protection of beach, dune, and wetland areas. More stringent standards for floodway delineation, such as "zero-rise floodways," would help protect wetlands, flood storage areas, and aquifer recharge areas.

CHAPTER IV

Footnotes

1. See Kusler (1980).
2. For a discussion of mitigation approaches see Swanson (1979). See also references at footnote 28.
3. See Nordstrom and Psuty (1979).
4. Fla. Stat. Ann. §§ 161.052, 161.053 (West Supp. 1982).
5. N.C. Gen. Stat. §§ 113A-100 to 113A-134 (1978).
6. See Section 4 of Greeson *et al.* (eds.) (1979), and the many papers therein.
7. See for example, Fosberg (1971), Savage (1972), and Teal and Teal (1969).
8. See Teal and Teal (1969).
9. For discussion of the erosion control and wave attenuation functions of other types of wetlands see, for example, Newcombe *et al.* (1979), and Wayne (1974).
10. See Kusler *et al.* (1979).
11. See Grant and Patrick (1970). See also the papers and many references contained in Greeson *et al.*, (eds.) (1979).
12. Greeson *et al.* (eds.) (1979), Section 6, p. 490.
13. Greeson *et al.* (eds.) (1979), Section 8, p. 589.
14. Greeson *et al.* (eds.) (1979), p. 652.
15. U.S. Department of the Interior (1978).
16. Colo. Rev. Stat. §§ 24-65.1-201 *et seq.* (Supp. 1981).
17. See the references on wetlands in the bibliography of this report.
18. 33 U.S.C. § 1344(a) (1978).
19. 33 U.S.C. § 403 (1970).
20. See Kusler (1978).
21. *Id.*
22. 16 U.S.C.A. § 1454 (West Supp. 1982).
23. For a description of these programs, see references in the coastal areas section of this bibliography.

24. See Kusler (1980), p. 30, 187.
25. See Kusler (1980), p. 26.
26. Mich. Comp. Laws Ann. § 281.76 (West Supp. 1979).
27. For information on agricultural zoning see the bibliography for this chapter. See also Toner (1978), U.S. Library of Congress (1978), and Toner (1981).
28. For discussion of riparian habitat protection programs see Johnson and McCormack (coordinators) (1979).
29. See Kusler (1979a), for the conclusions and recommendations of a technical seminar series investigating problems and approaches for better coordination of wetland and floodplain management efforts.

CHAPTER V
STATE PROGRAMS

Overview

The decade of the 1970s was one of growth and redirection in state floodplain management. Arizona, Colorado, Maryland, New York, Oklahoma, Pennsylvania, and Vermont adopted new statutes. Massachusetts and Rhode Island strengthened floodplain regulations by amending wetland protection acts to include the 100-year floodplain. California, Massachusetts, North Carolina, Rhode Island, and Washington incorporated coastal hazard mitigation provisions into state coastal zone management programs.

Prior to 1970, 24 states had adopted statutes authorizing either direct state regulation of flood hazard areas or state standard-setting for local regulation. By 1980, with the addition of the seven mentioned above, the number had reached 31, although some programs were limited to selected floodplains. Of the remaining 19 states, at least 10 provided technical assistance to local floodplain regulatory programs. All 50 states appointed coordinators for the National Flood Insurance Program. Under its State Assistance Program, FEMA now provides funds to 48 states to increase state administrative capabilities.

Principal state floodplain management activities during the last decade were varied.

The NFIP

States aided FEMA in implementing the NFIP. The rapid growth of the NFIP and resultant redirection of state programs has led to the appointment of NFIP state coordinators within each state, and to a shift in program priorities. Prior to 1970, programs in California, Iowa, Minnesota, Washington, and Wisconsin emphasized state regulation and mapping. During the last five years, state program staffs have spent

TABLE 7

STATE PROGRAM ACTIVITIES

	Ordinances			Hydrology Hydraulics				Enforcement of Violations				
	Prepare model	Assist in Adoption	Assist in Adm.	Training Local Officials	Review	Approval	Insurance Activities	Training Lenders & Agents	Information & Distribution	Monitoring Administration	Assist Locals	State Action
ALABAMA				X			X		X			
ALASKA	X			X			X					X
ARIZONA	X			X			X		X			X
ARKANSAS	X			X			X		X			X
CALIFORNIA	X			X			X		X			X
COLORADO	X			X			X		X			X
CONNECTICUT				X			X		X			X
DELAWARE				X			X		X			X
FLORIDA				X			X		X			X
GEORGIA				X			X		X			X
HAWAII				X			X		X			X
IDAHO	X			X			X		X			X
ILLINOIS	X			X			X		X			X
INDIANA	X			X			X		X			X
IOWA	X			X			X		X			X
KANSAS	X			X			X		X			X
KENTUCKY	X			X			X		X			X
LOUISIANA	X			X			X		X			X
MAINE	X			X			X		X			X
MARYLAND	X			X			X		X			X
MASSACHUSETTS	X			X			X		X			X
MICHIGAN	X			X			X		X			X
MINNESOTA	X			X			X		X			X
MISSISSIPPI	X			X			X		X			X
MISSOURI	X			X			X		X			X
MONTANA	X			X			X		X			X
NEBRASKA	X			X			X		X			X
NEVADA	X			X			X		X			X
NEW HAMPSHIRE	X			X			X		X			X
NEW JERSEY	X			X			X		X			X
NEW MEXICO	X			X			X		X			X
NEW YORK	X			X			X		X			X
NORTH CAROLINA	X			X			X		X			X
NORTH DAKOTA	X			X			X		X			X
OHIO	X			X			X		X			X
OKLAHOMA	X			X			X		X			X
OREGON	X			X			X		X			X
PENNSYLVANIA	X			X			X		X			X
RHODE ISLAND	X			X			X		X			X
SOUTH CAROLINA	X			X			X		X			X
SOUTH DAKOTA	X			X			X		X			X
TENNESSEE	X			X			X		X			X
TEXAS	X			X			X		X			X
UTAH	X			X			X		X			X
VERMONT	X			X			X		X			X
VIRGINIA	X			X			X		X			X
WEST VIRGINIA	X			X			X		X			X
WASHINGTON	X			X			X		X			X
WISCONSIN	X			X			X		X			X
WYOMING	X			X			X		X			X
DIST. COLUMBIA	X			X			X		X			X
PUERTO RICO	X			X			X		X			X

much of their time assisting or acting as contractors for FEMA mapping, distributing literature, answering questions on the NFIP, reviewing ordinances adopted by communities to qualify for the program, preparing manuals, and, in some instances, assisting FEMA in monitoring community performance.

Mapping

During the 1970s, states assisted federal floodplain mapping programs by establishing technical map standards (which often exceeded federal standards), and by aiding the NFIP and its contractors in acquiring topographic maps, flood flow information, and other flood-related data. Some states mapped floodplain areas independently at greater scales and higher levels of accuracy than required by FEMA. For example, New Jersey mapped floodplains and floodways at a scale of 1"=400'. Maryland placed NFIP flood boundaries on tax maps at a scale of 1"=600'. Colorado mapped some urban areas at a scale of 1"=200'. Florida, Michigan, and New Jersey defined coastal setback lines that accounted for erosion, something not considered in FEMA mapping. Maryland, Minnesota, New Jersey, and Wisconsin formed their own depositories for storage and distribution of flood data.

Regulation

By 1980, 31 states had established programs that either directly regulated all or a portion of their floodplains, or established standards for local regulation. State regulations were often more restrictive than those of the NFIP. More restrictive standards for delineation of floodway areas were adopted by New Jersey (0.2-foot rise), Maryland (no rise in many circumstances), Wisconsin (zero-rise in most circumstances), Minnesota (variable rise of 0.0- to 0.5-foot), Illinois (0.1-foot rise in rural areas, 0.5-foot rise in urban areas), and Indiana (0.1-foot rise). In addition, many states added freeboard requirements to the

100-year base flood elevation. For example, Wisconsin incorporated one foot of freeboard in mapping the 100-year floodplain.

Model Ordinances

At least 31 states developed model zoning or subdivision ordinances tailored to state laws and special needs to help localities develop their own regulations. Many models followed the overall framework suggested in Volumes 1 and 2, Regulation of Flood Hazard Areas. Minnesota and Wisconsin developed a whole series of model ordinances to be used with flood data of various types.

Procedural Manuals

At least 18 states adopted procedural manuals to assist local governments in regulation. Manuals addressed adoption and administration of regulations, flood insurance, postdisaster response, and other aspects of floodplain management.

Public Project Review

Most state programs reviewed state and federal projects in the floodplain through state regulatory permit requirements, state executive order requirements (e.g., California, Wisconsin), A-95 review procedures, or National Environmental Policy Act (NEPA) procedures.

Training and Education

At least 36 states conducted workshops and training sessions for local government officials, lenders, landowners, lawyers, and others. Training and education also took place on a one-to-one basis for local government officials and landowners.

Permit Review

Many states assisted local governments in evaluating proposed permits and subdivision plats. These evaluations were particularly

important for counties and smaller communities without technical staff or those which had only approximate flood maps with no 100-year flood elevations or floodways delineated.

Coordination

Some state floodplain management programs (e.g., Minnesota and Wisconsin) were closely coordinated with shoreland zoning programs. Other states (e.g., North Carolina and Massachusetts) tied theirs to coastal zone or wetland programs. Coordination with other land and water planning and management programs (such as pollution control) was an increasingly important function in many states.

Nonregulatory Techniques

Many state programs combined regulatory and nonregulatory floodplain management techniques. For example, New Jersey appropriated \$22 million for a cost-sharing program with local governments to construct flood control works; Pennsylvania allocated money to acquire flood-damaged properties; Maryland supported a cost-sharing program that stressed acquisition and relocation through a \$7,500,000 bonding authority; and Wisconsin provided money to local units to upgrade floodplain mapping. Using money from Title II of the Water Resources Planning Act of 1965,¹ several states initiated pilot studies on various floodplain management options. Other innovations to supplement regulations are outlined below:

- Flood Warning Systems

Pennsylvania has completed a pilot project to use flood insurance studies and maps for flood warning and evacuation.

Minnesota used money from the Water Resources Planning Act of 1965 to assess the usefulness of various types of flood warning systems in different parts of the state.

- Training and Education

Louisiana is preparing curriculum materials for university planning schools that stress floodplain management and hazard mitigation.

Illinois has developed manuals on state regulatory programs and the NFIP for local governments. It has also developed a homeowners' self-help manual to deal with flood problems. Plans are under way to develop an extension course on floodplain management for local officials who administer the program.

- Public Awareness

Maryland has promoted the use of signs to identify the 100-year floodplain or historical high water marks. Anne Arundel and Montgomery Counties have installed such signs.

Minnesota assisted the City of Crookston to place floodplain signs identifying 100-year flood elevations on street corners.

Colorado has placed signs in Big Thompson Canyon saying, "In case of flash flood, climb to safety." Signs have also been placed in other high-risk canyons in the Front Range of the Rockies.

California presented awards to five communities for wise use of floodplains.

- Hazard Mitigation Planning and Implementation

After a 1979 flood disaster in Indiana, the state assisted two communities in demolishing and relocating severely damaged residences and businesses. The state also helped the communities secure HUD Block Grants to rehabilitate structures.

Illinois assisted the City of Wilmington in preflood hazard mitigation planning. Several alternatives have been identified and discussed.

Minnesota is supporting preflood hazard mitigation planning in cities threatened by the failure of emergency levees.

- Floodproofing

Massachusetts has developed a state floodproofing program in response to the 1978 "northeaster" which destroyed many coastal residences.

Several states, including Massachusetts, Minnesota, and Virginia, have incorporated floodproofing regulations into their state building codes.

- Acquisition and Relocation

Pennsylvania provided flood disaster bond money to communities to aid them in acquiring flood damaged properties for open space use.

Maryland's new bonding authority authorizes funds for flood damage mitigation measures that stress acquisition and relocation and planning for floodplain management on a watershed basis.

Mississippi used HUD Section 407 funds to relocate 292 low-income family units; 84 units are being rehabilitated and floodproofed.

Rhode Island has under way a feasibility study for acquisition and relocation of flood-prone properties in several areas.

In cooperation with the Corps, Arizona is relocating a portion of Allenville and several other flood-prone communities.

Wisconsin has assisted Soldiers Grove to get funding for relocating its entire business section to a flood-free site.

The Kansas State Floodplain Coordinator's office has been relocated to higher ground from its previous location in the floodplain.

Program Emphasis

Program emphasis varied during the 1970s, depending on state legislation, budgets, and needs. Well-conceived and specific legislation did not necessarily mean strong programs. For example, a highly specific Connecticut statute authorized the State Water Resources Commission to adopt encroachment lines for rivers and streams. Because of budgetary and political considerations, however, none were delineated during the 1971-1980 period. On the other hand, Massachusetts successfully encouraged the adoption of many local floodplain regulations as part of wetland protection programs, despite its lack of clear floodplain regulatory powers. Other programs with small budgets and weak legislation reviewed public projects and provided technical assistance to local governments.

During the first year of a new program, states usually adopt administrative regulations, establish map priorities, and develop procedural manuals for local governments. After a program is well established (e.g., Iowa, Minnesota, New Jersey, and Wisconsin), emphasis shifts to implementation: evaluation of development proposals (permits submitted directly to the state or referred to the state by local governments), more specific mapping, review of local ordinances, and technical assistance to localities. States typically emphasize cooperation and coordin-

ation with other state and local programs such as coastal zone management, shoreland, wild and scenic river, and "critical area" programs.

Funding

State program performance varied from state to state, depending on staffing, funding, leadership, support from the governor, frequency of flood disasters, and other similar influences. Examples of staff and funding levels follow:

- New Mexico - 1 part-time person, \$5,000 budget.
- Texas - 3 full-time people, \$80,000 budget.
- California - 3 full-time people, 1 part-time person, \$164,400 budget.
- Rhode Island - 3 part-time people, \$14,000 budget.
- Iowa - 10 full-time, 16 part-time people, \$400,000 budget.

Problems

Major impediments to the implementation of state programs are much the same for each state.

- Lack of staff--Some states do not have a single full-time staff person assigned to floodplain management. Others have one or two. Only a dozen have more than two, and only five states have more than 10.
- Lack of funds--Funds for salaries, travel, conducting workshops, mapping, computer analysis of permits, and dissemination of materials are often inadequate.
- Lack of expertise--Staff in most states lack expertise in one or more of the subjects important in floodplain management such as floodproofing, regulations, insurance, relocation, and natural areas evaluation. Even where engineering expertise is available, other biological, cartographic, or planning expertise is often lacking.
- Inadequate statutory authority--Many state regulatory statutes are inadequate in one or more respects. Some lack sufficiently

broad powers (e.g., statutes applied only to floodways) or are handicapped by exemptions. Enabling authority is totally lacking in some states, particularly in the South and parts of the West.

- Inadequate flood data--Lack of detailed flood maps has been a serious constraint on most programs but most seriously where statutes require detailed mapping prior to direct state regulation or state standard-setting for local regulation. Because of budgetary restraints, most states rely primarily on NFIP maps, even though the state staff considers map scales only partially satisfactory for regulatory purposes.
- Conflicts between state and federal policies--Although many federal programs have aided state floodplain regulations, in some instances federal programs have undercut state policies. NFIP policies are often less stringent than state policies in coastal erosion areas. Subsidized federal flood control policies also undercut regulations, and federal disaster assistance has encouraged in situ rebuilding after a disaster. In the past, federal grants-in-aid policies for sewers, roads, low-income housing, and other projects did not adequately account for flood hazards. As a result, public floodplain uses or public infrastructure were located in floodplain areas, attracting unprotected private uses.
- Fragmented statutory authority--In many states floodplain management authority is split among several agencies, creating conflicts and leadership questions. Fragmentation of local regulatory authority has also been a problem.
- Problems with existing uses--Existing structures in flood-prone areas are often a major impediment to effective regulations, as discussed in Chapter III.
- State-local political conflicts--Larger cities often oppose state intervention, contending that they have sufficient expertise and personnel to deal with flood problems.
- Lack of landowner awareness--Landowner ignorance of flooding is a serious problem in many communities, particularly along the Florida and Atlantic Coasts, which have not experienced a major hurricane for more than 20 years. Landowner awareness of flood problems is high after a flood, but often falls off sharply in a few months.

Variations in State Regulations

There are three principal state floodplain management approaches: state standard-setting for local floodplain regulation, direct state regulation of flood hazard areas, and state standard-setting and/or direct regulation of flood hazard areas as part of broader resource protection programs.

State Standard-setting for Local Regulation

Many states authorize state standard-setting for local regulation of flood hazard areas. Direct state regulation of uses is usually authorized only if local governments fail to adopt and administer regulations meeting minimum state standards. States using this approach are Arizona, Arkansas, California, Colorado, Michigan, Minnesota, Montana, Nebraska, New York, Vermont, and Wisconsin. Some states, such as California and Nebraska, have standards for or directly regulate only floodway areas.

Several variations on this approach are illustrated below. Wisconsin required communities to adopt regulations by a specified date (January 1, 1968). Minnesota, in a more common approach, requires that communities adopt regulations within a specified time after adequate flood maps become available. California illustrates a third approach, which involves state cost-sharing for flood control measures where communities adopt regulations meeting state standards.

Wisconsin. Wisconsin has under way one of the oldest and most comprehensive floodplain management programs in the nation. The program was established in 1966 by a statute requiring that all communities adopt floodplain zoning by January 1, 1968.² The statute was prompted by severe flood problems along the Mississippi River and many smaller rivers such as the Fox and Chippewa. The shores of Lake Michigan and Lake Superior have flooding and erosion problems. Of the approximately 550 flood-prone communities, more than 300 have now adopted zoning ordinances.

The 1966 statute authorized the state to adopt regulations in the event of local inaction. Beginning with two people, the state program staff has grown to 11 headquarters positions and 17 part-time positions in six district offices, with a total 1980 budget of \$4 million.

During the 1966-1972 period, the program performed various tasks. First, communities with serious flooding were identified. Administrative regulations with minimum standards for local regulations were then developed. Several model ordinances and procedural manuals linked to available flood data were developed. Workshops with county boards and local governments were held throughout the state. Assistance in carrying out mapping was sought from the Corps of Engineers, the U.S. Geological Survey, and the Soil Conservation Service.

The Wisconsin floodplain management statute was adopted in conjunction with a shoreland zoning statute that required counties to zone shorelands (defined to include floodplains) to achieve broad, multipurpose objectives such as pollution control and protection of recreation values.³ Early training sessions, manuals, and other materials addressed shoreland as well as floodplain issues.

The floodplain program at first favored detailed floodplain and floodway mapping for the entire state--some 33,000 miles of rivers and streams--but cost and the prospect of changing watershed conditions discouraged such an ambitious effort. The program staff then recommended, and subsequently implemented, a revised approach relying on two types of maps: approximate flood maps for rural areas, and more detailed ones for urban areas. Approximate flood maps and the regulations linked to them were to be based on historic flood data and soil maps; more detailed maps were to be based on new engineering studies that defined flood profiles and, in some instances, floodways.

Wisconsin has promoted implementation of the NFIP although it has had difficulties with it (as have many other states) since the state standards on freeboard, floodway delineation, and other matters exceed the NFIP's. The Wisconsin program has come to rely on a "natural" floodway concept that allows no appreciable increases in flood heights.

However, the NFIP definition of a floodway allows a one-foot rise in flood heights. Moreover, map scales of the NFIP were often too small for effective community or state use. Consequently, the state legislature adopted a cost-sharing program to assist local governments in developing more detailed topographic maps.

The program staff has focused efforts on technical assistance and training and education for rural areas and small communities that lack personnel and expertise. It has assisted communities such as Prairie du Chien and Soldiers Grove in supplementing regulations with acquisition and relocation. The Southeastern Wisconsin Regional Planning Commission has played the principal role in technical assistance and mapping for urban Wisconsin in the seven southeastern counties near Milwaukee.

Community regulations resemble state models in most areas. However, a significant number of communities exclude all development from wetland and floodplain areas. Southeastern Wisconsin communities have adopted "environmental corridors" to protect not only floodplains but also wetlands, slopes, and bluffs within river corridors.

Problems with the Wisconsin program are insufficient staff and funds, inadequate flood data, and ambiguous enabling authority.

Minnesota. Flooding in the 87 Minnesota counties has been severe along the Mississippi River, the Red River of the North, the St. Croix, and many tributary streams. Floods in 1965 and 1969 caused \$160 million in damages. Lakeshore flooding caused by short- and long-term water level fluctuations was also a problem along many lakes in western and northern Minnesota. Approximately 645 Minnesota communities are flood-prone.

To reduce future flood losses, the Minnesota legislature adopted in 1969 a state floodplain management program in conjunction with a shore-

land zoning program much like Wisconsin's.⁴ This program now operates with an annual budget of \$200,000, two full-time headquarters staff people, and a part-time field staff of 25. At the local level, 210 communities have adopted ordinances; another 100 communities are under study and will be adopting ordinances in the near future.

The Minnesota statute, like Wisconsin's, authorizes the state Department of Natural Resources to establish standards for local regulation of floodplain areas. Most communities were required to adopt regulations within six months of receiving technical flood data and maps from the state. State regulation was to take place only in the event of local inaction. Basing the deadline on the availability of maps added another step to regulation and reinforced the need for mapping. Nebraska and Montana statutes have similar deadlines.

In 1973, Minnesota amended its floodplain management statute to require flood-prone communities identified by the Department of Natural Resources to qualify for the NFIP by adopting regulations.⁵ The intent of the statute was multipurpose: to afford floodplain occupants the opportunity to purchase flood insurance, to accelerate floodplain mapping, and to require some form of local floodplain regulation.

The history of Minnesota's program is similar to Wisconsin's. It began with drafting of administrative regulations, model ordinances, and manuals. Workshops were held throughout the state. Standards for local regulations were adopted in 1970 and a state floodproofing code was adopted as part of the state building codes in 1975. The state also continued its active training, education, and technical assistance programs. It is presently assisting local governments to supplement regulations with land acquisition, relocation, and flood warning signs.

Problems with the Minnesota program include conflicts between state and less restrictive federal standards and insufficient personnel and funds.

California. California has had a wide variety of flooding, mudslide, and erosion problems. Although much of the coast consists of bluffs and is subject primarily to erosion hazards, flooding from tsunamis and coastal storms is severe in Humboldt Bay and some other areas. Inland flooding occurs along the Sacramento and other major rivers. Flooding from rainfall and snowmelt in the mountains along dry channels is a serious problem in southern California. Approximately 435 communities are subject to significant flooding.

To address these problems, the California legislature adopted a variety of programs to establish standards for state or local regulation of flood hazard areas.⁶ A floodplain management law (the Colby-Alquist Act) was adopted in 1965. This statute authorized the Department of Natural Resources to map floodway areas and to establish minimum standards for local regulations. The state will share the cost of land acquisition for flood control if local governments adopt and administer satisfactory regulations. The 1980 funding for the program was \$164,600, with three full-time and one half-time staff members for each of the four district offices.

During its early phases, the program emphasized mapping. Later, emphasis shifted to training and education, permit evaluation, and technical assistance. Approximately 200 communities have adopted regulations on their own initiative to comply with state law or to qualify for the NFIP. Through onsite visits, the staff monitors community compliance with regulatory standards.

Other programs also address flooding problems. The State Department of Real Estate and affected local governments must approve residential land subdivision.⁷ Subdividers must investigate flood potential: development of unsafe sites is prohibited.

The 1972 state wild and scenic river program also reduces development in some flood-prone areas.⁸ This program requires that counties with designated rivers develop management plans for the watershed areas in cooperation with the state.

Coastal communities are required to adopt hazard regulations by still another statute--the Coastal Zone Management Act of 1972.⁹ The Coastal Commission issues the guidelines for local regulations. Pursuant to this program, communities such as Santa Barbara have adopted building setbacks for bluff areas.

Problems in the California program are fragmentation of authority, severe development pressures, lack of detailed flood maps, and insufficient personnel and funding.

Direct State Regulation

Ten states have directly regulated flood hazard areas. Washington regulates selected floodways, Michigan and Montana regulate floodplains and floodways throughout the state, Illinois regulates selected floodways and floodplains, Indiana, Kentucky and New Jersey regulate floodways, Maryland and Rhode Island regulate floodways and inland floodplains, and Florida, Maine, and Vermont regulate large-scale development in floodplains and floodways. The last three states also authorize optional local regulations.

Three types of direct state regulation are discussed below: direct state regulation of floodway areas with optional local regulation of other areas (Washington State), direct state regulation of floodways with mandatory local regulation of flood fringe areas (New Jersey), and direct state regulation of both floodway and flood fringe areas (Maryland).

Washington. Washington is subject to severe flooding along the Columbia, Cowlitz, and other rivers. In addition, its coast is peri-

odically flooded by storms and tsunamis. Approximately 270 communities have flood problems; of these, 85 have adopted floodplain zoning ordinances.

Washington adopted one of the first state floodway regulatory programs in 1935, when the legislature adopted a channel encroachment law in response to severe flooding. In 1936, the state adopted a broader Flood Control Zone Act that authorized the Department of Water Resources to identify and regulate flood hazard zones.¹⁰ Between 1936 and 1970, the state identified hazard zones in 93 communities along 18 streams: state permits are required for development in these zones. No new hazard zones have been identified since 1970.

The Washington legislature also authorized local zoning of floodplain areas and authorized the Department of Water Resources to delegate permit powers for state-identified zones to communities. To date, only four localities have permit powers--King, Clark, and Cowlitz Counties, and the City of Kelso.

The state program is staffed by five professionals and has funding of \$100,000 annually. Its principal duties are to process permits for proposals in state flood control zones, monitor development proposals, assist FEMA in mapping floodplains, and provide technical assistance to communities.

As in Wisconsin and Minnesota, the 1971 Washington legislature also authorized cooperative state/local shoreland zoning.¹¹ Shorelands were defined to include all areas within 2,000 feet of coastal or estuarine waters, 200 feet of lakes, and 200 feet of streams. Floodplains were also included. All local governments were required to adopt "master programs" for these areas. State standards require that protection against flooding be included as one element of the programs. Particularly strong emphasis has been placed on flood and erosion along the

2,400 miles of coast in 15 counties. The state has prepared a coastal atlas showing the 100-year frequency tide level, wave action and erosion areas, and geologically unstable zones.

Problems with the program include its small staff, insufficient funds, and inadequate flood data.

New Jersey. New Jersey is subject to severe inland and coastal flood problems. A 1954 hurricane caused extensive loss of life and property damage along 127 miles of beach. Winter storms such as the severe Ash Wednesday storm of 1962 are also a source of damage. Approximately 550 communities are flood-prone.

In 1929, New Jersey became one of the first states to regulate channel encroachments. In 1962, the legislature broadened floodplain management to include the delineation and marking of flood hazard areas. In 1972, the legislature adopted a comprehensive regulatory statute authorizing the State Water Resources Board to map floodplain areas, directly regulate floodways, and establish standards for local regulation of flood fringe areas.¹² The Board is authorized to regulate flood fringe areas directly if local governments fail to regulate these areas according to minimum state standards within 12 months of receiving the state maps. The statute also requires local tax assessors to reduce property taxes in state-delineated floodplain areas.

A staff of 10 people is implementing the program. Mapping is a principal activity. Working as a contractor to FEMA, the state has prepared maps at a scale of 1"=200' with five-foot contour intervals. Over 1,000 miles of stream have been mapped with floodways reflecting no greater than a 0.2-foot rise in surface water elevation. Monitoring is also emphasized. The staff plans to visit all of its flood-prone communities in 1981. Other program activities include permit processing, development of model ordinances, and training and education.

Floodplain regulations are supplemented by nonregulatory measures. A 1978 Emergency Flood Control Bond Act established a three-year program providing the New Jersey Department of Environmental Protection with \$22 million in matching funds to assist local governments to construct flood control works on a 50-50 basis and \$3 million to prepare a statewide flood control master plan and assist with development of regional flood control plans.¹³

New Jersey has not adopted floodplain regulations for coastal areas; however, the 1970 legislature adopted a coastal wetland protection act that requires permits from a regulatory agency for fill or dredging.¹⁴ Very little development is permitted in wetlands. In addition, the legislature adopted the Coastal Area Facility Review Act of 1973 that authorizes the division of coastal resources to regulate residential development of more than 25 units and major public and industrial facilities.¹⁵ A 1980 coastal zone management plan emphasizes flood hazard reduction.

Maryland. Maryland has storm surge and wave problems along its 5,000 miles of coast and the Chesapeake Bay, inland flooding along major rivers, and flash flooding along mountain streams in the west. Approximately 115 communities are flood-prone; 51 of these have adopted floodplain regulations in compliance with the regular phase of the NFIP.

In 1967, the state first adopted regulations for the 50-year floodplain as part of its state water pollution control program. Expanded legislation in 1976 required state permits for development within the 100-year inland floodplain.¹⁶ The State Water Resources Administration was also directed to map and mark floodplains. Communities were authorized to regulate floodplain areas and to adopt comprehensive floodplain management plans.¹⁷

Pursuant to this statute, the state has established a very active implementation program with a staff of 35 in the floodplain management and watershed permit divisions and a yearly budget of \$550,000. Principal activities include evaluation of 800 floodplain permits each year, mapping technical assistance, coordination of state, federal, and local programs, and monitoring of floodplain activities. The state has prepared maps at a scale of 1"=600' with tax maps as a base. Rather than using the NFIP encroachment standard, Maryland has developed a "tractive force" floodway which has taken into consideration the velocity and erosive force of water.

Because direct state regulations apply to all inland areas, the NFIP has permitted Maryland communities with nontidal streams and floodplains to enforce state floodplain regulations through adoption by reference. Both state and local approval is required for permits. Many communities such as Baltimore, Howard County, and Prince Georges County have adopted regulations exceeding NFIP standards, including prohibition of development within the 100-year floodplain and stormwater management regulations.

The state is also assisting communities with nonregulatory measures such as floodproofing and comprehensive stormwater management. It has begun comprehensive watershed management plans. The legislature adopted a \$7.5 million bond issue in 1980 to assist communities in implementing flood hazard mitigation projects. Communities are to emphasize acquisition and relocation. In 1981, the legislature approved use of those funds for watershed and hazard reduction planning.

State floodplain regulations do not apply to coastal areas, but Maryland has adopted a statute that requires permits for filling and construction in coastal wetlands from its Water Resources Administration.¹⁸ Flooding is one consideration used in evaluating permits. In

addition, the Maryland Tidewater Administration provides grants-in-aid and technical assistance on flood hazard mitigation to coastal communities.

Problems with the program are lack of regulatory powers for coastal areas, lack of maps for some areas, and insufficient personnel for monitoring.

Flood Hazard Regulation as Part of Broader Resource Management

Many states either directly regulate selected floodplain areas or establish standards for local regulation pursuant to planning or resource protection statutes. California, Oregon, and Nevada mandate local planning and regulation with natural hazards protection as one component. Many coastal and some inland states directly regulate or establish standards for local regulation of wetland areas. Other states include floodplain management as part of coastal zone management programs.

Three ways in which flood hazards are regulated through broader resource management programs are illustrated below: regulation of inland and coastal flood hazard areas through a combination of wetland and coastal zone management (Massachusetts), regulation of inland floodplains through a combination of state encroachment lines and wetland regulations defined by soil type (Connecticut), and regulation of coastal flood hazard areas through a coastal zone management statute (North Carolina).

Massachusetts. Much of the 1,200 miles of Massachusetts coast is subject to severe hurricane and "northeaster" flood problems. Flooding is also a problem along rivers in the central portions of the state and in the central and western mountains. A coastal storm in February of 1978 killed 29 and destroyed or damaged 11,000 structures.

Massachusetts has not adopted a comprehensive floodplain management statute, but does have a number of specific statutes that provide con-

siderable state and local control over both inland and coastal floodplains. In 1961, the legislature authorized state encroachment lines for the Assabet River, but not for other rivers. It also authorized a state permit system for coastal wetlands in 1963,¹⁹ the first such system in the country. From 1965 to 1980, the state made considerable progress in adopting coastal wetland protection orders pursuant to this and later statutes. The orders apply to many of the most seriously flooded coastal areas. Restrictions are recorded on deeds, and permits for structures and fill within these areas must consider flooding.

In 1973, the legislature authorized local conservation commissions to regulate coastal and inland wetlands.²⁰ The real strength of the Massachusetts program for inland areas lies in this statute. In a 1975 amendment, wetlands were defined to include the 100-year floodplain.²¹ Local regulation of wetlands is supervised by conservation commissions in each Massachusetts town. These appointed commissions are often highly conscientious and function with much greater expertise in evaluating wetlands permits than do traditional zoning boards. Denial or issuance of local permits may be appealed to a state appeal board.

In evaluating permits, local commissions consider how a proposed use will affect flooding. In general, local commissions deny permits in wetland or floodplain areas. In addition to wetland regulations, many flood-prone Massachusetts communities have adopted floodplain regulations with standards equaling or exceeding those of the NFIP.

The Massachusetts Coastal Zone Program has also addressed flood and erosion hazards. All coastal wetlands and barrier islands have been mapped. Through this program, the state provides community assistance grants (totalling \$241,000 in fiscal 1981) to coastal communities. Technical assistance is also provided.

Other state hazard reduction initiatives resulted from the severe winter storm of 1978. After this storm, a disaster task force was formed to guide recovery efforts. Floodproofing standards accounting for wave heights were incorporated into the state building code. The state adopted a bond issue to provide funds to local governments for acquisition of floodplain lands. In August 1980, the governor issued an executive order declaring a general state protection policy for coastal beaches and prohibiting the use of state funds for development in beach areas.²²

The fragmentation of regulatory powers has complicated floodplain management in Massachusetts; nevertheless, the resulting "package" of programs appears to be quite effective. Other problems are inadequate maps, lack of expertise, and strong development pressures. The NFIP is also viewed as a mixed blessing because FEMA standards are less restrictive than those of most communities and because subsidized insurance creates pressures for development.

Connecticut. Hurricanes caused severe loss of life and property damage along the Connecticut coast during 1938 and 1954. There is inland flooding along the Connecticut and other major rivers. Approximately 170 communities are subject to flooding.

Connecticut was one of the first states to implement a floodway encroachment statute when the legislature in 1955 authorized the Water Resources Commission to identify and require permits for development in floodway areas.²³ The state has identified approximately 300 miles of floodway.

Although some measure of direct control over floodplains continues under this statute, staffing (two person-years) and budget (\$35,000) are small. The most extensive state program for inland floodplains is the Wetland Regulation Program, authorized by the state legislature in 1972.

Wetlands are defined by statute to include alluvial, poorly drained, and very poorly drained soils. Between 20%-25% of the state, including much of the floodplain, is encompassed by this broad definition. Wetlands throughout the state have been mapped with the help of the Soil Conservation Service.

The 1972 Inland Wetland Law requires that local governments regulate inland areas according to state standards.²⁴ The Department of Environmental Protection is authorized to regulate directly wetland areas in the event of local inaction. To date, 116 communities have complied with state standards. The Department directly regulates wetlands in the remaining 53 towns. Under this statute, development or filling is strongly discouraged. Many towns also adopted separate floodplain regulations in order to qualify for the NFIP. Combined wetland and floodplain standards are usually more restrictive than those required by the NFIP.

The state also directly regulates coastal wetlands under a coastal wetland statute adopted by the legislature in 1971. Flooding threats are considered in permit evaluation.²⁵

To facilitate wetland, floodplain, and other land management efforts, the state has established a centralized natural resource data gathering and mapping program. This program coordinates topographic, floodplain, wetland, and other mapping elements and supplies maps and interpretive materials to localities. Detailed air photos, soils maps, and topographic maps (7.5-minute quadrangles) are now available for the entire state. Separate pamphlets listing data sources have been compiled for each community.

Problems with the Connecticut program are fragmented enabling authority, lack of direct state floodplain regulatory powers for coastal areas, and inadequate staffing and funding.

North Carolina. Hurricane and storm flooding and associated erosion along the "outer banks" and behind barrier islands affect the entire North Carolina coast. Flooding occurs along rivers in the coastal plain, and flash floods and other high velocity floods are a problem in the western mountains. Approximately 410 communities are subject to flooding.

In 1971, the legislature adopted a statute authorizing and directing local governments to regulate the 100-year floodplain.²⁶ The Board of Water and Air Resources was authorized to map floodplain areas and assist local governments in mapping. However, the Board was not granted regulatory powers.

Although the state inland floodplain management program has no regulatory powers, it has assisted communities and FEMA in developing flood insurance study maps and encouraged communities to enroll in the NFIP. A nine-person field staff provides technical assistance.

More floodplain management has been implemented along the coast. In 1968, the legislature adopted a dune protection statute that required counties to adopt regulations to control vegetation removal in dune areas.²⁷ All six coastal counties have adopted dune protection ordinances. In 1969, the legislature adopted a state-administered coastal wetland protection act regulating dredging or filling activities in coastal areas.²⁸

In 1973, the legislature adopted a comprehensive coastal zone management act that required local governments to identify coastal areas of environmental concern and to adopt regulatory standards consistent with state criteria.²⁹ Areas of environmental concern are defined to include (but are not limited to) sand dunes, beaches, floodplains, and erosion areas. The program formulated coastal hazard mitigation standards that required not only elevation to the 100-year flood protection

level plus freeboard, but also erosion setbacks and protection for dune systems.³⁰ Flood and erosion maps are being prepared for the entire coast, as is an erosion control manual.

Problems in North Carolina's program are inadequate enabling authority, the lack of detailed flood and erosion data, federal standards that fail to account for erosion, inadequate monitoring and extensive existing development. The state, like most others, needs strengthened implementation. To accomplish this continued federal mapping is desirable if not essential.

CHAPTER V

Footnotes

1. Title III of the Water Resources Planning Act of 1965, P.L. 89-80, (codified at 42 U.S.C.A. § 1962d-1 (West 1981)).
2. Wis. Stat. Ann. § 87.30 (West 1975).
3. Wis. Stat. Ann. §§ 59.97(1), 144.26 (West 1975).
4. Minn. Stat. Ann. §§ 104.01 to 104.07 (West 1978).
5. Minn. Stat. Ann. § 104.08 (West 1978).
6. Cal. Water Code § 8400 to 8415 (West 1971).
7. Cal. Bus. & Prof. Code § 11000 *et seq.* (West 1964). See particularly §§ 11018.4 and 11025.
8. Cal. Pub. Res. Code §§ 5093.50 *et seq.* (West Supp. 1982).
9. Cal. Pub. Res. Code §§ 30300 *et seq.* (West 1977).
10. Wash. Rev. Code Ann. § 86.16.010 *et seq.* (1981).
11. Wash. Rev. Code Ann. §§ 90.58.010 *et seq.* (1981).
12. N.J. Stat. Ann. §§ 58:16A-50 *et seq.* (1982).
13. N.J. Stat. Ann. § 58:16A-55.4 (1982). See also 1978 N.J. Laws ch. 78, "Emergency Flood Control Bond Act".
14. N.J. Stat. Ann. §§ 13:9A-1 *et seq.* (1979).
15. N.J. Stat. Ann. §§ 13.19-4 *et seq.* (1979).
16. Md. Nat. Res. Code Ann. § 8-9A-01 *et seq.* (Supp. 1981).
17. *Id.*
18. Md. Nat. Res. Code Ann. § 9-102 *et seq.* (1974).
19. Mass. Ann. Laws ch. 130, § 105 (Michie/Law Co-op 1981).
20. Mass. Ann. Laws ch. 131, § (Michie/Law Co-op 1981).
21. Mass. Ann. Laws ch. 131 § 40 (Michie Law Co-op 1981).
22. Commonwealth of Massachusetts Executive Order No. 181, August 13, 1980.
23. Conn. Gen. Stat. §§ 25-4a *et seq.* (1981).
24. Conn. Gen. Stat. §§ 22a-36 *et seq.* (1981).

25. Conn. Gen. Stat. §§ 22a-28 *et seq.* (1981).
26. N.C. Gen. Stat. §§ 143-215.51 *et seq.* (1978).
27. N.C. Gen. Stat. §§ 1048-3 (repealed 1979 N.C. Sess. Laws ch. 141, § 1.
28. N.C. Gen. Stat. §§ 113-229 *et seq.* (1978).
29. N.C. Gen. Stat. §§ 113A-100 *et seq.* (1978).
30. N.C. Gen. Stat. §§ 113A-113 (1978).

CHAPTER VI

LOCAL PROGRAMS

Status of Programs

As noted in Chapter I, the 1970s witnessed much growth in local floodplain management and increasing sophistication in the application of regulations in combination with other hazard reduction techniques. More than 17,000 cities, towns, villages, and counties have adopted or shown an intent to adopt regulations to qualify for the NFIP or to satisfy state floodplain management requirements.

Local regulation of floodplain areas is largely a phenomenon of the 1970s, although some cities, such as Milwaukee, adopted regulations in the 1940s and 1950s. A 1957 national assessment of floodplain regulations by Francis C. Murphy at the University of Chicago identified only 35 local governments with regulations.¹ He considered most of these programs ineffective.

By 1970, several hundred communities had adopted regulations. A University of Wisconsin survey of local regulations in 1968-1969 identified 183 municipalities and 71 counties with floodplain zoning, and 167 municipalities and 27 counties with flood-related subdivision regulations.² These communities were centered in two areas of the nation: the Tennessee Valley, where TVA had provided flood hazard maps and technical assistance since 1953; and the midwestern states of Iowa, Wisconsin, and Minnesota. In the late 1960s, the latter two states had adopted state floodplain statutes mandating local regulations.

Rapid local adoption of floodplain regulations since 1970 is attributable primarily to the incentives of the NFIP, although other various forces have also been important: serious and widely publicized floods such as those resulting from Hurricane Agnes, widespread availability of

flood maps, the development of model ordinances and floodplain regulation guidebooks, technical assistance from state and federal agencies, state statutes authorizing and often requiring floodplain regulations, concern with floodplain environmental values, and increased community land use planning and control capability. In general, local governments have adopted the minimum standards of the NFIP except where state standards are more restrictive.

Differences in Rural, Urban, and Metropolitan Areas

Rural Areas

Many rural communities and counties have adopted a resolution requiring floodplain development permits from a planning commission or board of adjustment. Others have adopted a single district floodplain zoning ordinance of the sort proposed in Volumes 1 and 2, Regulation of Flood Hazard Areas. Approximate flood maps developed by the USGS, historic flood maps, and soils maps provide the basis for regulation.

Rural communities are often handicapped in regulation by lack of detailed maps, personnel, funds, and expertise. State technical assistance has been particularly important for rural areas since state programs often provide model ordinances and manuals, training, and case-by-case review of permits. Regional planning agencies have also provided important technical assistance.

Highly restrictive rural regulations are most common in riverine areas of the Northeast, Midwest, and the mid-Atlantic states. In these areas, permanent dwellings are sometimes prohibited in the entire floodplain. Single-district zoning regulations are often combined with subdivision controls and sanitary regulations. Some subdivision regulations are combined with sanitary code provisions that prohibit septic tanks in hazard areas in order to control some development without zoning.

Often "resource protection" regulations are adopted for all or portions of rural floodplains. As discussed in Chapter V, inland wetland protection regulations have been widely adopted in Connecticut, Massachusetts, New York, and Rhode Island. State or local coastal wetland protection regulations have been applied in all coastal states. Shoreland regulations have been adopted in Maine, Michigan, Minnesota, New Hampshire, Wisconsin, and Washington State. Agricultural zoning has been adopted for some floodplain areas in California, Oregon, and Massachusetts. Wild and scenic river zoning with floodplain components has been applied to selected rivers in Maryland, Michigan, Minnesota, New York, Oregon, and Wisconsin. Some Colorado communities have adopted zoning to protect sand and gravel resources in floodplain areas.

Urban Areas

Many small and medium-sized cities have two-district floodplain zoning (floodway or coastal high hazard area and a flood fringe), subdivision control, and building code regulations. Two-district zoning is often applied to developed urban areas. Single-district zoning is common for smaller streams or those without detailed flood studies. Two-district regulations usually resemble the models set forth in Volume 1, Regulation of Flood Hazard Areas.³ Subdivision regulations often contain drainage requirements. Building codes establishing minimum protection elevations without zoning are common in coastal areas. Urban areas usually adopt floodplain regulations as part of broader zoning and land use controls.

Expertise and staffing are problems for smaller cities, but less so than for rural areas. Detailed flood maps are available for some but not all urban areas. State assistance in mapping and project review has been somewhat less important for urban areas than for rural ones.

Metropolitan Areas

Large cities and metropolitan areas have adopted the most sophisticated floodplain management programs and regulations. Two-district floodplain zoning is common; however, some large cities such as Baltimore and Milwaukee exclude new development from the floodplain. Subdivision regulations with flood hazard and storm drainage provisions are found in many cities. Building codes may incorporate flood hazard provisions.

These areas have often developed more detailed flood maps with scales of 1"=100' to 1"=400' with 2-foot to 4-foot contour intervals. Mapping on a watershed basis is common: future watershed conditions are often considered. Sewer maps, topographic maps, and other large-scale maps may be used as bases.

Large cities and metropolitan areas often have engineering and planning staffs with some expertise in floodplain management. Regulations are typically combined with acquisition, flood control works, and urban renewal policies. Integrated floodplain and stormwater management regulations may be provided for smaller streams.

Program Characteristics

The most extensive survey of local floodplain regulation during the 1970s was conducted by the Center for Urban and Regional Studies at the University of North Carolina. In April of 1979, with funding from the National Science Foundation,⁴ the Center sent questionnaires to 1,515 local governments and 648 regional agencies. The results of the survey are summarized below.

Local Government Responses

The 1,515 surveyed communities included 926 communities in the regular program of the NFIP and 489 in the emergency program. Community response to the questionnaire was an excellent 85%.

Regulatory objectives. As one might expect, most communities in both the regular phase and emergency phase adopted regulations to reduce property loss from flooding (73% and 53%, respectively) and to prevent threats to safety (69% and 50%). Reduction in erosion and sedimentation was also a major objective (43% and 36%), as was preservation of natural areas (41% and 35%).

Techniques. The regulatory techniques used for both phases were similar, but with different emphases. Both groups relied heavily on elevation requirements (84% and 63%) as part of permit systems, zoning, or other regulations. However, as one might expect, regular program communities, because they have more detailed flood maps, made greater use of elevation requirements. Subdivision regulations, which shift much of the data-gathering burden to developers and thus can be used with approximate flood data, were used with about the same frequency (76% and 75%). Both groups used zoning regulations (77% and 71%), which is somewhat surprising since other information suggests that zoning is more common in regular program communities. Floodproofing requirements were used more frequently in regular program communities (68% to 40%) because more detailed flood data and the personnel needed to evaluate development proposals are available there. As expected, floodway regulations were more common for regular program communities (60% to 35%), since floodway maps are usually available only for them.

Most communities devoted limited resources to program implementation. Fifty percent spent less than \$1,000 a year on implementation (44% and 58%), and an additional one-quarter spent less than \$5,000 (27% and 22%). Fifty percent spent less than one hour of staff time each week on regulations (44% and 62%) and another one-third spent less than seven hours per week (41% and 29%).

Several circumstances contributed to the development of comprehensive programs: severe flood hazard, higher perception of flood hazard, and community concern for the problems. Community land use control experience and financial resources were also important.

Program effectiveness. After analysis of the number of permits issued in regular and emergency phase flood insurance program communities, the researchers concluded that local floodplain management programs were not halting continued development of floodplains. This was to be expected since most communities followed minimum NFIP and state standards which permit flood-protected structures in outer fringe areas. However, flood protection through elevation on pilings or fill was routinely required.

Local officials rated their floodplain management programs very effective in dealing with new development (62% and 49%). However, only 15% and 14%, respectively, rated their programs as effective in dealing with existing development.

Floodplain regulations were considered very effective in protecting natural areas for about one-fourth of the communities (30% and 23%) and moderately effective in an additional one-half (51% and 53%). This low response rate could be expected since most regulations permit development within outer fringe areas and, in some instances, in floodways, providing flood flows are not substantially increased.

Negative effects of regulations were reported in some communities. Increased construction costs were cited in fewer than one-half of the communities (50% and 36%). Reduced land values were cited in fewer than one-quarter (22% and 15%). Slowed economic growth affected fewer than one-sixth (16% and 13%) and reduced tax base about one-tenth (13% and 9%). On the other hand, some communities (10% and 5%) cited increased value of existing structures outside of the floodplain.

Problems. Communities cited several major obstacles to effective management: the general populace did not perceive floods as a problem (35% and 46%), land development interests opposed regulations (36% and 31%), sufficient state or federal financial support was lacking (32% and 35%), floodplain occupants opposed efforts (27% and 20%), qualified personnel were lacking (19% and 24%), and public officials were insufficiently interested (17% and 23%).

Regional Council Responses

The North Carolina group also sent a questionnaire to all 648 members of the National Association of Regional Councils. Ninety percent responded.

The floodplain management objectives reported by the regional councils were similar to those reported by local communities; however, 47% also reported maintenance of good water quality as a goal--reflecting the influence of the Environmental Protection Agency Section 208 Areawide Water Quality Management Program. Many councils were concerned with inadequate storm drainage (58%) and increased runoff from impervious surfaces (48%). This also could be expected, since regional planning agencies often deal with regional hydrology and drainage problems.

The majority of the regional councils used five floodplain management methods: (1) providing technical assistance to local governments (82%), (2) incorporating flood hazard reduction measures in regional planning (75%), (3) using the A-95 review process to discourage public investment in floodplains (61%), (4) making the public aware of flood hazards (16%), and (5) coordinating local programs (44%). A principal technical assistance and educational role could be expected since regional planning agencies usually lack regulatory and implementation powers.

Although the agencies were interested in floodplain management, most (84%) spent less than one-half person-day per week on the subject. When asked to evaluate the overall effectiveness of programs within their jurisdiction, only 7% rated programs as very effective.

Regional councils identified five major obstacles to expanded regional action in floodplain management: lack of financial support (81%), lack of public support (72%), member agency resistance to area-wide policies (61%), lack of interest by policy board (59%), and failure of the public to perceive flooding as a regional problem (57%).

Both local governments and regional councils gave high marks to state floodplain management. Seventy-eight percent of local respondents said that their states were active in floodplain management. Of this 78%, 80% rated the state programs as moderately or very effective. State agencies had provided technical assistance to 40% of the surveyed communities.

Sixty-one percent of the regional agencies reported that the NFIP was having the most significant impact of any federal program on protecting lives and property from flood losses. An overwhelming majority of local governments also reported that they had received technical assistance from the NFIP. However, 37% reported that they needed better maps, and 23% said they needed more help in calculating elevations for new development.⁵

Problems

The North Carolina study and the present study identified major problems in implementing local programs. Many have already been discussed.

- Lack of personnel and funds (particularly in small communities).
- Lack of expertise in floodplain management techniques and the use of flood data.
- Lack of familiarity with or understanding of NFIP requirements for basements, floodproofing, and base flood elevations.
- Inadequate maps (no copies, not completed, inadequate scale, no floodways, inaccuracies, lack of adequate topographic base).
- Existing nonconforming uses.
- Exemptions in regulations.
- Problems with mobile homes.
- Inadequate procedures for monitoring development.
- Special flood problems such as erosion, alluvial fan flooding, and lake flooding, that are not addressed by NFIP standards.
- Federal, state, and local public projects (e.g., low-income housing) in the floodplain.
- Conflicts between federal and state standards.
- Development pressures and lack of flood-free construction sites.
- Court cases or threats of litigation.
- Inadequate enabling authority.
- Communities' boundaries too small to deal with the source of flood problems (e.g., uncontrolled development in headwater areas in other political jurisdictions).
- Federal subsidies for flood control works.
- Federal flood insurance subsidies encouraging development in barrier islands, beach areas, wetlands, and other floodplain areas.
- Lack of landowner and community awareness of the severity of flood problems.

Innovative Programs

Types of Innovation

Some communities have adopted innovative regulations to cope with the above problems, or to deal with other needs such as allocating lands

throughout communities to their most cost-effective uses.⁶ California, Connecticut, Massachusetts, New Jersey, New York, and Wisconsin have many innovative local programs. These programs often serve as examples for new programs in other communities. Innovations are of several major types, many of which have been described in preceding chapters:

- Building moratoria adopted after a disaster.
- Coastal regulations incorporating wave heights or freeboard, particularly strict dune and beach and vegetative protection standards, and wetlands protection provisions.
- Inland regulations exceeding NFIP and state standards, including zero-rise floodways, regulations to a lower frequency of flooding (e.g., the 500-year level), freeboard requirements, and storm drainage requirements.
- Regulations that reduce flood losses but also serve broader objectives such as protection of prime agricultural lands, mineral deposits, forestry areas, and wetlands.
- Regulations combined with flood warning systems, acquisition, relocation, flood control works, and flood warning signs to reduce losses to future and existing uses and, in some instances, to serve broader objectives.

Factors Encouraging Innovation

Innovations were most common when one or more of the following factors were present.

Most innovative programs were located in inland communities with recurrent and serious flood problems (e.g., Warwick, Rhode Island; Klamath, California). Innovation was less common in coastal communities with severe flooding, perhaps because of offsetting development pressures. Although severe flooding was the principal motivation for innovation, environmental problems also fostered some programs.

Because of a serious flood threat and a high level of community awareness, innovative communities often adopted regulations before the NFIP came into existence or a state floodplain program was initiated. Regulations were often adopted within two weeks to six months of a particularly serious flood. In several instances, such as Lilydale,

Minnesota, regulations were quickly adopted in anticipation of a severe flood so that the community could qualify for the NFIP.

Recent innovative programs were often encouraged by federal and state maps, technical assistance, grants in aid, flood control works, flood insurance, and other assistance. However, many innovations were initiated before federal or state assistance was available.

Strong local leadership was evident in the most innovative programs. A local planner, architect, engineer, the mayor, or a city council member often provided key leadership, although interested citizens and elected officials were important in some programs. The extreme nature of the flood problems created a political climate conducive to such leadership.

Multipurpose planning and creative thinking were evident in most programs. "Larger thinking" that goes beyond dealing with the flood threat characterized most innovative programs. Urban renewal, recreation, wildlife protection, and open space protection were common additional concerns.

Examples of Community Approaches

Broad thinking and community acceptance of responsibility for the future economic, social, and environmental well-being of its residents underpin many of the innovations profiled below.*

Resource-based Regulations for a Rural Floodplain (Glastonbury, Connecticut)

Glastonbury, a rural New England town of 25,000, has been repeatedly and severely flooded by the Connecticut River, which flows through the

*The examples have been selected from profiles contained in Appendix B to this report, Innovation in Local Floodplain Management.

town for 7.5 miles. About 1,900 acres, much of them in agriculture and open space, lie within the 500-year floodplain.

Prompted by a general awareness of flood problems and environmental concerns, in 1963 the town adopted restrictive, resource-based regulations to reduce future flood losses and protect valued resources. A floodplain zoning ordinance controlled land use and prohibited almost all permanent structures and fill in the 500-year floodplain. The town adopted a density transfer scheme, which permits the shifting of development rights from one part of a parcel to another with a shift of one unit per acre. The state also regulated some of the floodplain pursuant to a state floodway encroachment statute.

In 1974, local floodplain regulations were supplemented by wetland regulations which apply to most floodplain areas. Wetlands were mapped at a scale of 1"=100'. Fill and structures were prohibited in wetland areas. Restrictive agricultural zoning was also adopted for some areas.

The city supplemented floodplain regulations by acquiring some areas and providing tax incentives for open space uses. A group of private citizens formed the Glastonbury Trust to acquire floodplains and wetlands.

Keys to the success of this program include motivated and aware citizens, sound flood and wetland data, responsive government officials and staff, and a creative combination of regulations and nonregulatory techniques.

Regulations Combined with Acquisition (Sacramento County, California)

Sacramento County is an urbanizing area that includes the City of Sacramento and its 800,000 residents. Floods along the American River, the Sacramento River, and a number of smaller creeks have damaged the city and the county repeatedly. These damages and a concern for recrea-



Glastonbury, Connecticut, excludes structures from the 500-year floodplain along the Connecticut River which is zoned for wetland, agriculture and open-space use.

Photo by Jon Kusler

tion and other values led to planning, floodplain acquisition and the adoption of regulations.

The county first adopted floodplain regulations in the mid-1960s requiring that residences be three feet above the 10-year flood elevation. This standard was later amended to one foot above the 100-year flood. The county also adopted subdivision and storm drainage regulations: a natural stream plan incorporates highly restrictive standards for one area of the county.

Extensive lands along the American River have been acquired. A greenbelt plan for the river dates from 1915, but it was essentially unimplemented until the 1960s. In 1961, after the County Planning Commission approved subdivision plans for a portion of the American River floodplain, citizens reacted strongly and formed the Save the River Association. Public pressure forced the county board to adopt a parkway plan. Funding from a variety of sources, including a county bond issue, has been used to acquire more than 3,000 acres along 23 miles of the river. The remaining 1,900 acres in mixed public-private ownership are controlled through leases and special arrangements. A County Park Corridor Overlay Zone prevents incompatible adjacent development.

The regulations and acquisitions have been successful because of timely regulations and acquisition before development could occur, high public awareness, an active citizen lobby, effective staff leadership, and available funding.

Regulations Combined with Postdisaster Relocation (Soldiers Grove, Wisconsin)

Soldiers Grove is a small southwestern Wisconsin town (population 680) which has been subject to repeated flooding by the Kickapoo River. Prior to 1978, the Corps of Engineers had constructed levees adjacent to the river, but these provided only partial protection from flooding.

The Corps also began construction of a 9,500 acre upstream dam and reservoir, but public opposition throughout the state halted the project.

In 1978, the town adopted floodplain regulations requiring that new structures be elevated one foot above the 100-year flood level. The town redevelopment authority also prepared a relocation plan. Later that year a severe flood overtopped the levees and flooded the entire town, causing \$52 million in damages. Upgraded floodplain regulations prohibited rebuilding in the Kickapoo River floodway which includes most of the downtown. After this event, the redevelopment authority prepared a new relocation plan and the town adopted it. With a variety of funding sources, a 190-acre site for a new town was acquired and sewer and water supply facilities were installed.

The relocation plan is presently being implemented at an estimated total cost of \$5.75 million with 60% federal and 40% nonfederal cost-sharing. Thirteen structures have been constructed at the new town site. Passive solar heating is required by ordinance as part of wider resource planning measures and to increase available grant sources. In addition, several residential structures in outer flood fringe areas have been elevated on fill or floodproofed with technical assistance and financial help from the town.

The success of this program has been due to the severity of the flood threat, strong leadership by the local redevelopment authority, education regarding the cost effectiveness of floodplain management, and the packaging of federal funds. This is among the most innovative of all local programs. It combines the objective of flood loss reduction with provisions for urban renewal, open space, and energy conservation. It demonstrates the importance of preflood planning that makes mitigation programs available for quick implementation when a flood occurs.



In relocating its flood-prone business district after the severe flood in 1978, Soldiers Grove, Wisconsin, also required passive solar construction for its new buildings in the new town.

Photo by Jon Kusler

Floodplain Regulations Combined with Stormwater Management Regulations

(Dallas, Texas)

Dallas is a rapidly growing city of nearly one million residents. There has been repeated severe flooding, with a particularly serious flood in 1964. Because of flood problems and the need for recreation and open space, the city adopted a comprehensive floodplain regulation, stormwater management, acquisition, and relocation program.

Floodplain zoning was first adopted in 1965. In 1968, the city adopted regulations for the 100-year floodplain. In 1977, regulations were upgraded so that the city now allows only minor floodplain changes that will cause no increase in flood heights. Restrictions were imposed on nonconforming uses. A permit from the board of adjustment is required for any alteration or improvement valued over \$300. The city also adopted subdivision and stormwater management regulations.

To implement regulations and facilitate watershed planning, detailed flood maps for 35 to 40 creeks at scales of 1"=50' to 1"=200' were developed on an orthophoto base with one- or two-foot contour intervals. These maps were based on flood flow projections assuming fully urbanized conditions consistent with land use planning and regulatory densities.

When a residential subdivision is developed, the subdivider ordinarily must dedicate the floodplain to the city as a condition to plat approval. Flood boundaries must be indicated on plats and marked on the ground.

The floodplain may not be used as a building site for apartments. However, floodplain portions of broader parcels intended for apartment use may be used as common open space if a floodway easement is dedicated to the city. Density bonuses are given for floodplain protection. Certain residential subdivisions have also been permitted to retain title to floodplain areas where a homeowners' association agrees to hold and maintain the land as open space.

Regulations have been supplemented by acquisition of more than 2,500 acres of undeveloped floodplain. Funding has been received from a variety of sources, including local bond issues; one landowner donated 400 acres. In addition to acquisition of undeveloped areas, the city acquired approximately 180 structures in two seriously flooded subdivisions through a voluntary relocation program. HUD Community Development Block Grant monies and other funds were used.

The city has undertaken some channelization to reduce flooding threats to existing uses, and it is acquiring and constructing stormwater retention basins.

The success of this program has been due to severe flooding problems, motivated and informed citizens, effective city council leadership and staff, high quality flood maps, and multiple funding sources.

Multijurisdictional Floodplain Management (Denver Metropolitan Area)⁷

The Denver metropolitan region consists of 34 units of local government with 1,100 miles of floodplain, a population of more than 1,200,000, and a total area of about 1,200 square miles. The area has been subject to repeated and severe floods along the Platte River and Cherry Creek.

In 1969, the Colorado Legislature created the Denver Urban Drainage and Flood Control District to address drainage and flood control problems on a metropolitan basis. Individual local entities were unable to deal with multijurisdictional flood and drainage problems. The District includes Denver and the urban portions of Adams, Arapahoe, Douglas, and Jefferson Counties. The District is governed by a 15-member board of directors. Funds are obtained by a tax levy.

The District is authorized to regulate floodplain areas but has chosen, instead, to establish standards for local regulation by the 28 local governments with flood problems. All 28 communities adopted

regulations by a deadline the District established; they are also enrolled in the NFIP.

The District has prepared detailed flood maps and master drainage plans for most areas. The drainage plans identify present and anticipated basin problems, flood flows based on projected urbanized watershed conditions, and measures needed to reduce flood problems. Thirty-one master plans had been prepared as of December 13, 1979. Planning is under way for six other areas.

Other District activities are the design and construction of drainage and flood control facilities, provision of technical assistance to local government, collection of flood and water quality data, preparation of flood disaster plans, and education of landowners.

Floodplain management activities have received strong support from citizen groups such as the Platte River Development Committee, which has lobbied for the protection and restoration of the Platte River. In 1974, the District prepared a "greenway" plan for that part of the river flowing through downtown Denver. The plan is now being implemented to improve water quality, enhance recreational opportunities, provide open space, and reduce flood losses. Over 350 acres of greenway along 10 miles of the river have been acquired with public and private funds. The Greenway Foundation, a nonprofit corporation, has played a major role in public relations and fund-raising for the program.

Success with the greenway plan has been due to a high level of awareness of flood problems, special enabling legislation, citizen support, effective staff, a thorough public education effort, and careful coordination of activities.

Two-zone Management of Coastal Flood Problems (East Providence,
Rhode Island)

East Providence is a city of 52,000 with estuarine flooding on the Seekonk River. The waterfront suffered severe flood damage from hurricanes in 1938 and 1954. Following recommendations of a governor's task force on hurricane flood problems in 1955, the city adopted regulations prohibiting structures on lands less than 10 feet above mean sea level. If protected from flooding, structures for human occupancy were permitted in backlying areas between 10 and 15 feet above sea level. These regulations are still in effect.

The city acquired some floodplain areas for public use after the 1954 flooding. In 1974, it prepared a waterfront plan for the 14.4 miles of city waterfront. Additional park acquisition is recommended by the plan.

The success of this program has been due to the severity of flood problems, an active city planning office and conservation commission, and state coastal zone and wetland regulations that reinforce local controls. East Providence illustrates one of the oldest approaches to "high hazard area" and "low hazard area" coastal flooding in the nation.

Coastal Flood Hazard Reduction and Resource Protection (Virginia Beach,
Virginia)

Virginia Beach is a coastal community of 285,000 with a large coastal floodplain and some riverine flooding. There was severe flooding in 1933 and 1962.

The city first adopted floodplain regulations in 1973, requiring permits for all activities involving fill, grading, or structures. First floors must be elevated one foot above the 100-year flood elevation. Development is prohibited in areas less than six feet above mean sea level. In one beachfront area subject to wave action, first floors

must be elevated 18.5 feet. The community has adopted its own flood maps at a scale of 1"=100'.

The city has also adopted coastal wetland regulations and sand dune protection regulations that require building setbacks. Four coastal inspectors have been hired by the city to monitor and enforce regulations. In addition, private citizens have helped by reporting violations.

Success in this program has been due to community awareness of flood and environmental problems, support by the city administration, and detailed flood maps. Virginia Beach illustrates a successful combination of floodplain and wetland regulations to achieve multipurpose floodplain management goals.

Mud Flows (San Bernardino, California)

San Bernardino is a southern California community of 170,000 residents. A 1979 forest fire north of the city denuded 750 acres in and adjacent to a canyon with unstable slopes. This, combined with heavy rainfall, caused increased runoff and mud flows. One area of the city was subject to four mud flows in January and February of 1979; 25 structures were seriously damaged.

Because of safety concerns, the city passed an emergency ordinance declaring the area unsafe and prohibiting new building or repair of damaged structures. Acquisition of damaged structures was made possible by funding from FEMA's Section 1362 program and loans from the Small Business Administration. The vacated land will be used as a city park. To contain future flows, retaining walls were constructed adjacent to the properties. In addition, the city has undertaken erosion control work in the headwaters of the canyon.

Success of this program has been due to the severity of the problem, public awareness, support of the city council and mayor, public education, and federal financial assistance. San Bernardino illustrates one

community's approach to a "special" flood problem using a combination of management techniques.

Similar floodplain management programs tailored to mud flows, alluvial fan flooding, long-term ground water fluctuations, high velocity flows, combined erosion and flooding and other special flood problems are needed in thousands of communities. These could be encouraged by state and federal technical assistance and "special" mapping.

CHAPTER VI

Footnotes

1. Murphy (1958).
2. U.S. Water Resources Council *et al.*, (1970).
3. *Id.*
4. French and Burby (1981).
5. *Id.*
6. Sanibel, Florida; Lake County, Illinois; and Lincoln, Massachusetts, are examples of such broader resource management efforts that include floodplain management as one component.
7. For other examples see Platt *et al.* (1980).

CHAPTER VII

FLOODPLAIN REGULATIONS AND THE COURTS

Introduction

Between 1970 and 1980, judicial support for floodplain regulations was overwhelming. State supreme or appellate courts issued at least 55 reported decisions on floodplain regulations and 25 on wetland regulations. Federal courts addressed flood insurance issues in at least 25 decisions and Section 404 permit issues at least 20 times. The goals and techniques of floodplain regulation (outlined in Table 8) were unanimously endorsed. Problems, where they arose, concerned procedural matters and lack of data in evaluating permits. Courts held denial of a specific permit invalid in only seven cases, and those took place early in the decade. Even in these cases, the courts supported the general validity of regulations. In six of these there was either lack of evidence of flooding or a failure to show that the proposed use would have adverse individual or cumulative effects on flooding.¹

Floodplain regulations raise constitutional issues similar to those involved in broader land use regulatory efforts. In determining the constitutional validity of regulations, courts look first at the general validity of the regulations and then at their specific validity as applied to a particular landowner. They first decide whether the unit of government or agency adopting the regulation was authorized to do so by an act of Congress or a state statute, and whether statutory procedures were followed. Having found sufficient statutory powers and compliance with statutory procedures, they then decide whether the regulations (1) serve valid police power objectives, (2) have a reasonable tendency to achieve or aid in the achievement of those objectives, (3) afford equal treatment to similarly situated landowners, and (4) permit reasonable private use of land so that a "taking" of private property does not occur.

TABLE 8

REGULATORY GOALS AND TECHNIQUES

Goal	Regulatory Technique
1. Prevent land uses which will increase flood heights or velocities, resulting in flood damage.	<ol style="list-style-type: none"> <li>1. State and local regulations requiring permits for dams, levees, channel straightening, structures, or fill in floodway areas. <li>2. Zoning, subdivision and encroachment regulations preventing obstruction of floodways <li>3. Zoning ordinances controlling the types and densities of uses in flood storage areas <li>4. Subdivision or drainage regulations controlling drainage design <li>5. Soil conservation regulations requiring land treatment (soil and water conservation practices)
2. Prevent land uses which will cause other nuisances.	<ol style="list-style-type: none"> <li>1. Zoning, building codes, and other regulations controlling hazardous uses of the floodplain such as chemical treatment plants, oil and gas storage facilities, and nuclear power plants which may cause fires or other hazards during floods <li>2. Zoning and other regulations restricting storage of materials, placement of mobile homes, construction of wooden residences or other uses involving material that may be carried by flood waters onto other lands thereby increasing the force of flood waters and causing debris problems <li>3. Zoning and other ordinances regulating uses with water pollution potential such as sewage treatment plants, chemical plants, and solid-waste disposal sites

TABLE 8 (continued)

Goal	Regulatory Technique
3. Prevent victimization and fraud	<ol style="list-style-type: none"> <li>1. State and federal interstate land sale acts requiring that an accurate descriptive statement of the land be filed with appropriate regulatory agencies and prospective buyers <li>2. Zoning, building codes, state permits and subdivision review acts requiring that lands be physically suitable for intended uses
4. Reduce the costs of community services	<ol style="list-style-type: none"> <li>1. State and local capital improvement plans that restrict sewers, water lines, roads or other public facilities in flood hazard areas or require floodproofing of them <li>2. Zoning regulations requiring that utility connections to private structures be elevated to the flood level or protected in some other manner <li>3. Subdivision regulations requiring that developers install floodproofed facilities in new subdivisions
5. Promote most suitable use of land throughout a community, region or state	<ol style="list-style-type: none"> <li>1. Community-wide planning and zoning regulations based on land suitability guiding development away from sensitive areas <li>2. State or local regulations protecting prime agricultural lands, mineral resources and coastal areas <li>3. State statutes and local ordinances requiring environmental impact statements for development or subdivisions

During the last decade, most lawsuits contesting floodplain regulations did not challenge the general validity of restrictions (adequacy of basic power and compliance with statutory procedures), but rather contested the constitutionality of regulations as applied to a particular property in the context of these four basic tests. This "pinpoint" approach to the determination of constitutionality derives in part from two U.S. Supreme Court decisions issued in the 1920s. In *Village of Euclid v. Ambler Realty Co.*² the Court upheld the basic concept of zoning-- the division of a community into various districts and the application of different land use standards to each of the districts. Two years later, in *Nectow v. City of Cambridge*³ the Court again endorsed the general concept of zoning, but held that the regulations at issue were invalid as applied to particular lands. In this case, the Court faced a difficult dilemma. To have struck down the ordinance as a whole would have left the community without zoning and would have invalidated the regulations even where they made sense. Taking a compromise position, the Court held that zoning regulations could be valid in general but invalid as applied to particular property.

This approach has been followed by courts across the nation in floodplain and other cases. When arguing their claims, landowners may concede the general validity of a floodplain, wetland, or other regulation but argue that it is irrational, arbitrary, or capricious as applied to their land or that it "takes" their property without "just compensation". A court may find that the regulation is in fact unconstitutional as applied to particular property, but this will not stand as a determination of the constitutionality of the regulation as applied to other lands. A pinpoint approach favors general judicial acceptance of floodplain regulations; however, it has led to a fair amount of litigation.

General Judicial Responses

In 1969 and 1970 when Volumes 1 and 2 of Regulation of Flood Hazard Areas To Reduce Flood Losses were prepared, a considerable number of floodplain cases and more than 12,000 land use control cases had already been decided.⁴ From these it was possible to identify general trends in judicial decisions and to suggest how courts would likely treat floodplain issues that had not yet been resolved. Even so, many issues needed clarification and the issue of "taking" had not yet been widely litigated, particularly for open space flood fringe regulations. How well has the legal analysis of Volumes 1 and 2 fared? What clarifications have been provided or new directions developed in the past decade?

During the 1970s courts responded to the following general legal requirements for floodplain and resource protection regulations.

(1) The agency or local government adopting regulations must be authorized to do so by an enabling statute or home rule powers. Inadequately authorized regulations fail to meet due process requirements; they are considered ultra vires and invalid by the courts. Volumes 1 and 2 concluded that statutes authorizing local zoning, subdivision controls, building and other codes were sufficient to authorize floodplain zoning, subdivision control, or other regulations in virtually all states.⁵

In the 1970s no court invalidated regulations for lack of enabling authority. In fact, several cases commented upon the sufficiency of general enabling statutes, and several upheld the power of special districts to adopt regulations.* In addition, some courts held that local units had a duty to adopt floodplain regulations or consider flooding when required to do so by a particular statute: those courts directed compliance with the statutes.

* These and other cases will be cited in the more detailed discussion to follow.



Devastation at Klamath, California, after flooding in 1962; in Turner v. County of Del Norte, a California court upheld regulations prohibiting building of permanent structures in the area.

Photo source: U.S. Army Corps of Engineers

(2) Statutory procedures for adoption and amendment of regulations must be carefully followed, otherwise regulations violate due process requirements and are ultra vires. Volumes 1 and 2 concluded that prior comprehensive planning was not required for most floodplain regulations but that other procedural requirements must be followed.⁶

This general requirement was adhered to in the 1970s. One court held that an informally adopted floodplain "resolution" did not regulate because the local government had not followed procedures required for a formal ordinance. Several cases held the denial or approval of a special exception permit invalid because statutory procedures had not been followed. A Minnesota court, however, upheld adoption of an ordinance in an emergency without statutory notice and hearing because of the extraordinary conditions involved (flood waters were rising and the community needed to qualify for flood insurance).

(3) State land use regulations must not, in general, pertain to matters of exclusively local concern, otherwise state regulations may contravene local home rule statutes or constitutional provisions adopted in at least 35 states.⁷ Volumes 1 and 2 concluded that state or state-supervised floodplain regulations do not violate home rule powers because flooding is a multijurisdictional issue and of more than local concern.⁸

In the 1970s no court invalidated state regulations as violating local home rule powers. Courts in at least three cases specifically upheld regulations against claims that state regulations violated home rule provisions, concluding that flooding is a matter of greater than local concern. In addition, courts in at least six cases have upheld state coastal zone, wild and scenic river, and similar resource regulations against home rule arguments with no adverse decisions for such resource-based state regulations.

(4) Regulations must serve legitimate police power objectives.

Regulations that fail to do so violate due process requirements. Volumes 1 and 2 concluded that regulations designed to prevent landowners from increasing flood damages on other lands, threatening public safety, or causing victimization were clearly designed to serve valid objectives.⁹ The reduction of losses to the landowners themselves (which indirectly affect society) and the reduction of the need for flood control works at public expense were also considered valid objectives, although few cases had yet been decided on these points.¹⁰

Cases in the 1970s provided strong support for protection of public safety, and prevention of nuisances and victimization. Courts in some cases endorsed not only these traditional objectives but also regulations adopted to protect owners from flooding, protect flood storage, qualify a community for flood insurance, reduce flood losses, protect floodways until public purchase was possible, and reduce the cost of public services. No floodplain case invalidated regulations for failing to promote valid objectives; a number of cases specifically endorsed broad objectives.

Based on case law at that time, Volumes 1 and 2 gave guarded support to floodplain regulations adopted to serve wetland protection objectives.¹¹ This underestimated judicial response: cases in the 1970s gave overwhelming legal support for wetland and other environmental regulations. Floodplain regulations may now be adopted, with some confidence, to achieve not only hazard reduction but also wetland protection, dune protection, coastal zone management, and erosion control.

(5) Regulations must be reasonable; that is, the regulatory standards and procedures must have some tendency to accomplish the regulatory goals such as reduction in flood losses. If regulations are not reasonable, they violate due process requirements. Volumes 1 and 2

concluded that, in order to avoid due process problems, regulations must be based on sound flood data;¹² the degree of restriction must be reasonably related to the actual threat of flooding;¹³ and the restrictions must have some real tendency to reduce flood problems.¹⁴

Courts in the 1970s examined the factual base for regulations more carefully than in the preceding decade. Cases suggest that maps must be reasonably accurate but need not be at very large scale, particularly where procedures are available for refining data as individual permits are considered. Under most enabling authorities, regulatory agencies may consider the cumulative impacts of development in carrying out flood studies and determining floodway limits. Courts in five states specifically endorsed the determination of flood heights or floodway boundaries or the evaluation of development impacts that take into account cumulative impact of projected floodplain or watershed development. Regulations requiring protection to the 100-year flood level were specifically endorsed in several cases. However, courts in several other cases held the denial of a particular permit invalid in specific circumstances due to lack of sufficient evidence of flooding or erosion.

(6) Standards for agency action must not be vague or indefinite, otherwise regulations violate due process requirements. Volumes 1 and 2 concluded that broad hazard reduction standards were sufficient for issuance of special permits and variances by local zoning boards, planning boards, and state and federal agencies.¹⁵

In the 1970s courts sustained broad statutory and ordinance standards for issuance of special permits and variances when they were challenged. However, as noted above, some courts have found an insufficient factual basis (of erosion or flooding, for example) to deny or justify issuance of permits.

(7) Regulations must not discriminate between similarly situated landowners, otherwise regulations violate 14th Amendment due process requirements. Volumes 1 and 2 suggested that floodway regulations might need to provide equal conveyance of floodwaters along both sides of a stream to avoid due process problems and that similarly situated landowners may be required to elevate to similar elevations.¹⁶ However, Volumes 1 and 2 concluded that new uses could validly be treated differently from existing uses.¹⁷

In only a few floodplain cases were discrimination questions specifically considered. None invalidated regulations on this ground, although some suggested that regulations would be held invalid if found to be discriminatory. Courts strongly endorsed equal degree of encroachment and cumulative impact standards in floodway restrictions and quite often focused on equity considerations in deciding whether regulations were a taking of private property.

(8) Regulations must not "take" private property without payment of just compensation, otherwise regulations violate 14th Amendment and 5th Amendment requirements of due process and prohibitions against taking. Volumes 1 and 2 concluded that floodway and coastal high hazard area restrictions, subdivision regulations to prevent victimization, and elevation requirements for outer flood fringe areas do not take property, even where such restrictions severely affect private landowners.¹⁸ However, based upon cases up to that time, Volumes 1 and 2 warned that very strict regulation of outer fringe areas and "wetland restrictions" might be held a taking.¹⁹

With few exceptions, in the 1970s courts upheld floodplain regulations against taking challenges. Restrictions upheld included highly restrictive regulations for outer areas as well as for floodway and coastal high hazard zones.

(9) Units of government may not, under most circumstances, increase flooding or flood damages to private lands. Volumes 1 and 2 concluded that units of government ordinarily are not responsible for flood damages resulting from natural causes nor are they required to adopt regulations, provide insurance, undertake flood control works, or provide utilities.²⁰ However, under certain circumstances, government bodies may be responsible for increased flood damage on private lands under theories such as taking, nuisance, and trespass when the governmental unit constructs, operates or maintains flood control works, roads, or other public structures or facilities.

Despite a growing trend during the 1970s to hold governments responsible for positive actions resulting in increased flood losses, governments were not held responsible for failing to provide flood insurance, disaster assistance, flood control works, or floodplain regulations. Several federal court decisions refused to hold the Federal Insurance Administration liable for failure to broadly advertise the National Flood Insurance Program (NFIP). The courts held that the program had been adequately advertised. A relatively large number of decisions have addressed NFIP responsibility for payment of local insurance claims. Most of these involved interpretation of the flood insurance statutes.

A court held that individual members of a city council were not responsible for adopting floodplain regulations. Similarly, courts denied liability for operation of dams when damage resulted from an extremely severe flood. However, some courts have found local governments liable for operation and maintenance of inadequate drainage facilities, including those constructed by a subdivider and dedicated to the city.

In conclusion, the cases within the last decade have been, with minor exceptions, consistent with the legal analyses and conclusions of Volumes 1 and 2. Some points have been clarified. Most important, judicial support for floodplain and other resource management programs has been even stronger than expected.

Cases From The 1970s

What sorts of floodplain regulations have been litigated in the 1970s? Have the standards of the National Flood Insurance Program (NFIP)--which have become minimum standards for more than 17,000 communities--been widely contested?

The NFIP standards that require protection of floodway areas (where floodway maps are available) so that development will not increase flood heights more than one foot, and those that require elevation of structures in coastal and riverine flood areas to the 100-year flood elevation have not been widely litigated. Apparently, landowners or their attorneys have considered the chances of successful litigation remote. Instead, many of the 55 cases brought in the last decade have addressed regulations more restrictive than those required by the NFIP. As noted earlier, all but six decisions sustained the regulations and even these endorsed the concept, disagreeing only with the denial of a particular permit. In light of this overwhelming support, future disapproval of minimum NFIP standards is unlikely.

Floodway Regulations

Many states and localities have adopted restrictions for floodway areas that equal or exceed NFIP standards, which permit a one-foot increase in the height of the 100-year flood. Floodways as well as floodplains are calculated according to existing watershed conditions. Floodway restrictions, including some more restrictive than those of the NFIP, have been contested in several cases.

In Krahl v. Nine Mile Creek Watershed District,²¹ the Minnesota Supreme Court sustained a watershed district's floodway regulations that were intended to preserve flood storage and conveyance. The regulations required that encroachments in the floodplain not exceed 20% of the total floodplain area.

In Young Plumbing and Heating Co. v. Iowa Natural Resources Council, the Iowa Supreme Court sustained state regulations which required removal of a structure in a 200-foot-wide floodway where an individual structure and fill would have increased flood heights about .3 foot with a 1.7-foot calculated increase, assuming equal degrees of encroachment.

In Subaru of New England, Inc. v. Board of Appeals,²³ the Massachusetts Appeals Court sustained floodplain and floodway regulations designed to protect flood storage in the town of Canton where there was evidence that, although the particular development would have increased flood heights only 1/4 inch, potential cumulative impact might have been significant.

In Foreman v. State Department of Natural Resources,²⁴ the Indiana Court of Appeals sustained restrictive floodway regulations. Calculated flood heights took into account future watershed conditions.

In Maple Leaf Investors, Inc. v. State Department of Ecology,²⁵ the Washington Supreme Court upheld denial of a state permit for proposed houses in the floodway of the Cedar River pursuant to state regulations that prohibited habitable structures in floodway areas.

In Usdin v. State Department of Environmental Protection,²⁶ a New Jersey Superior Court upheld state restrictions prohibiting construction within a floodway area.

Control of Both Floodway and Fringe Areas

Courts upheld floodplain regulations exceeding NFIP standards by prohibiting or virtually prohibiting development in entire floodplains in several instances.



The Iowa Supreme Court in Young Plumbing and Heating Co. sustained the Iowa Natural Resources Council's refusal to issue a permit and ordered removal of this condominium, which was built without permit in a floodway. The condominium was subsequently torn down.

Photo source: Iowa Natural Resources Council

The Massachusetts Supreme Court in Turnpike Realty Co. v. Town of Dedham²⁷ sustained Dedham's floodplain regulations which restricted repeatedly flooded areas to open space uses such as "woodland, grassland, wetland, agricultural, horticultural, or recreational use." However, landowners could apply for special exception permits. The landowner argued that the regulations were a taking of private property since there was testimony that the land was worth \$431,000 before regulations and \$35,000 after regulations. The court disagreed.

In Dur-Bar Realty Co. v. City of Utica,²⁸ a New York court sustained highly restrictive regulations for a Utica floodplain conservancy area. The regulations limited uses to farming and agriculture, parks, golf courses, athletic fields, essential services, disposal facilities, landfill operations, and marinas.

In S. Kemble Fisher Realty Trust v. Board of Appeals,²⁹ a Massachusetts court upheld regulations that limited property to open space conservancy uses.

Similarly, in Turner v. County of Del Norte,³⁰ a California court upheld regulations that prevented permanent dwellings in a severely flooded area. Open space uses and seasonal camping were permitted.

Dune and Beach Regulations

Several cases addressed the validity of highly restrictive dune and beach setback regulations. In Spiegle v. Borough of Beach Haven,³¹ the Superior Court of New Jersey sustained a beach setback line for an area subject to severe storm damage and held that the line did not constitute a taking as applied to most properties. A lower New York court in Lemp v. Town Board³² held that dune regulations were invalid (although not a taking) as applied to a property in an area for which a permit had been issued and a later attempt made to revoke it.

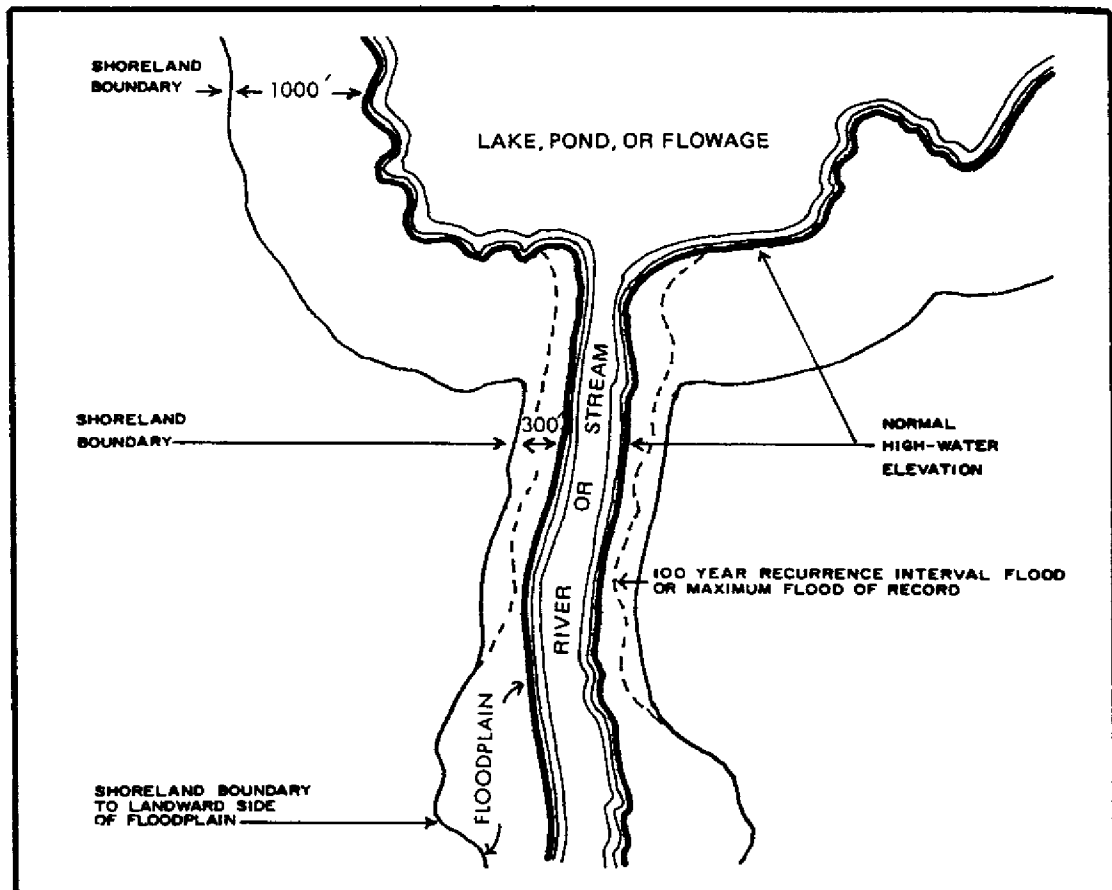
Interim Regulations

Courts sustained interim floodplain regulations in several cases. In Cappture Realty Corp. v. Board of Adjustment,³³ the New Jersey Superior Court upheld highly restrictive regulations until flood problems could be more thoroughly assessed. In Lindquist v. Omaha Realty, Inc.,³⁴ the South Dakota Supreme Court sustained restrictive regulations which prevented rebuilding in a devastated area of Rapid City after the disastrous 1972 flood.

Wetland Regulations

Both federal and state courts were asked to address a variety of wetland regulations controlling fill or dredging in wetlands. Federal courts, in a long line of decisions beginning with Zabel v. Tabb,³⁵ upheld denial of Federal Section 10 and Section 404 permits for development in coastal wetlands. Several cases involved denials of permits for dredging and filling in Florida mangroves,³⁶ which play important hazard reduction roles. Several decisions also addressed Federal 404 permit requirements for inland waters. One decision required Section 404 permits for agricultural activities in bottomland hardwoods along the Mississippi.³⁷ Flood storage was noted as a reason for protecting these areas. Other decisions held that permits are also required for development in wetlands along inland lakes.³⁸

Many state decisions also addressed wetland regulations. Most sustained restrictive regulations, particularly in the late 1970s. For example, a Maryland court in Potomac Sand and Gravel Co. v. Governor of Maryland³⁹ sustained the denial of a permit for dredging coastal wetlands in Charles County. The Rhode Island Supreme Court in J. M. Mills, Inc. v. Murphy⁴⁰ sustained wetland regulations for areas defined to include the 50-year floodplain. The Wisconsin Supreme Court in Just v. Marinette County,⁴¹ the most famous of the wetland decisions, strongly



The Wisconsin Supreme Court in Just v. Marinette County upheld county conservancy zoning for wetland areas adopted pursuant to a "shoreland zoning act."

Source: Southeastern Wisconsin Regional Planning Commission, Floodland and Shoreland Development Guide. Planning Guide #5, Waukesha, Wisconsin, 1968.

supported state-supervised shoreland zoning regulations adopted by Marinette County. These regulations placed lakeshore wetlands in conservancy districts. The New Hampshire Supreme Court in Sibson v. State⁴² upheld tight coastal wetland regulations, citing the Just case. In Graham v. Estuary Properties, Inc.,⁴³ the Florida Supreme Court upheld county refusal of a permit that would have resulted in the filling of 1,800 acres of red mangroves on Marco Island.

Special Permits

More than a dozen decisions focused on the adequacy of standards for issuance of special permits or the adequacy of the factual basis for issuance or denial of special exceptions, variances, or other special permits. Courts universally upheld the regulatory standards as providing sufficient guidance to regulatory boards. For example, in Dur-Bar Realty Co.,⁴⁴ a New York court upheld an ordinance which directed the board of adjustment to consider the impacts of the proposed uses on flood heights.

However, in several decisions courts found that local permitting boards lacked sufficient data to justify granting or denying specific permits. For example, in Pope v. City of Atlanta⁴⁵ the Georgia Supreme Court strongly endorsed a river protection act, including the standards for evaluating permits, but held that denial of a permit for a tennis court based on an argument of cumulative impact on runoff lacked factual support. On the other hand, courts in several jurisdictions found that permits had been invalidly granted because flood problems had not been adequately considered.⁴⁶

Subdivision Regulations and Stormwater Drainage

Several courts upheld flood and drainage standards in subdivision ordinances. In Brown v. City of Joliet,⁴⁷ the Illinois Appellate Court held that refusal to approve a plat was justified where a subdivider failed to include adequate plans for drainage and there was evidence

that without such provision the subdivision not only would have increased drainage problems in surrounding areas but also would have been subject to them itself. The court noted that "the storm water problem which would be created in this case would be uniquely attributable to plaintiff's subdividing and development."⁴⁸

In Hamlin v. Matarazzo,⁴⁹ the Superior Court of New Jersey held that in giving tentative approval to a subdivision for 43 homes on a 28-acre tract of undeveloped farmland, a planning board had improperly failed to consider effects of drainage and flooding. Drainage from the tract flowed onto plaintiff's land. A professional engineer testified that construction of the 43 homes would reduce stormwater absorption by 60% to 70%, substantially increasing erosion.

In Metropolitan St. Louis Sewer District v. Zykan,⁵⁰ the Missouri Supreme Court upheld sewer district regulations requiring construction of drainage facilities in subdivisions and ordered both construction of the facilities and payment of damages for failure to install facilities agreed to by the subdivider.

However, in Kessler v. Town of Shelter Island Planning Board,⁵¹ a New York court held that refusal to approve a subdivision subject to flooding was invalid because the subdivider was willing to fill the area to protect against flooding as required by the planning board, and because the planning board's ulterior goal was to preserve the entire area for recreational use. However, the court conceded that the subdivider might be required either to provide recreation areas on the site or to pay the town for park purposes.

Regulations in Anticipation of Acquisition

Floodplain regulations were quite often adopted for areas that were later to be publicly acquired for flood control, parks, or other public

purposes. Courts sustained such regulations where the principal objective was to prevent flood damages, not to reduce property values.⁵²

Judicial Response to Specific Challenges

A variety of specific legal challenges were posed to floodplain regulations in the cases discussed above.

Adequacy of Enabling Authority

In a few cases, landowners challenged the basic power of a local government to adopt floodplain regulations. Despite adoption of regulations by 17,000 communities between 1969 and 1980, no court invalidated regulations on the grounds of inadequate basic enabling authority: courts found sufficient powers in all cases where the issue was raised. For example, in Turnpike Realty,⁵³ the Massachusetts Supreme Court held that adoption of a floodplain zoning ordinance was valid pursuant to a Massachusetts statute authorizing towns to adopt zoning providing "that lands deemed subject to seasonal or periodic flooding shall not be used for residence or other purposes in such a manner as to endanger the health or safety of the occupants thereof."⁵⁴ The court noted that, even before the enabling act had been amended to include specific reference to flood, "we believe that a municipality could validly have enacted a floodplain zoning bylaw under the general grant of authority . . . (to promote the health, safety, convenience, morals, or welfare), and for the reasons . . . (to secure safety from fire, panic, and other dangers)."⁵⁵ A concurring opinion of the Oklahoma Supreme Court similarly concluded that municipalities had sufficient power to adopt floodplain zoning under a broad zoning enabling act.⁵⁶

The Colorado Supreme Court held that a county had sufficient power to adopt floodplain and mineral conservation zones under a broad enabling statute.⁵⁷ The Washington Supreme Court held that a statute authorizing a state agency to regulate flood hazard areas was sufficiently broad to

justify denial of permits for residences in floodways.⁵⁸ The South Dakota Supreme Court held that Rapid City was exercising a valid use of police powers when it adopted regulations prohibiting issuance of building permits for an area devastated by the June 12, 1972 flood, until a planning study was complete.⁵⁹

Courts in several jurisdictions held that the powers of special districts were sufficiently broad to authorize adoption of floodplain regulations. In Metropolitan St. Louis Sewer District⁶⁰ the Missouri Supreme Court upheld sewer district regulations requiring construction of drainage facilities in subdivisions. The regulations had been adopted pursuant to a broad grant of powers to deal with sewage. Similarly, in Krahl,⁶¹ the Minnesota Supreme Court upheld the floodplain encroachment and elevation requirements of the watershed district since the district had a general grant of power to deal with problems of water use.

In County of Ramsey v. Stevens,⁶² the Minnesota court went beyond a mere affirmation of local powers when it sustained a lower court decision ordering a local community (Lilydale) to adopt regulations. A special statute required that communities designated by the Minnesota Department of Natural Resources adopt regulations to qualify for the NFIP, but Lilydale had failed to comply with this statute.

In Hamlin,⁶³ the New Jersey Supreme Court held that not only were local subdivision review powers sufficiently broad to require drainage facilities, but also they imposed an affirmative duty upon the local planning board to consider flooding. The court held that a planning board had improperly failed to consider effects of drainage and flooding when it gave tentative approval to a subdivision for 43 homes on a 28-acre tract of undeveloped farmland and ordered the board to do so.

The Need to Follow Statutory Procedures.

In a few cases, landowners argued that state or local regulations had not been adopted or administered in a manner consistent with statutory procedures. Several cases held regulations partially or wholly invalid where adoption procedures were not followed. In Jefferson County v. Johnson,⁶⁴ the Alabama Supreme Court held that a county building code and a county resolution adopted to qualify for the NFIP were not sufficient in themselves to authorize the county engineer to deny a permit for construction in a floodway area: a more formal zoning regulation was needed. In Morland Development Co. v. City of Tulsa,⁶⁵ the Oklahoma Supreme Court held that floodplain zoning adopted as an amendment to other zoning was invalid because it was adopted without notifying landowners in writing as the zoning enabling act required for zoning amendments. In A. H. Smith Sand and Gravel Co. v. Department of Natural Resources,⁶⁶ the Maryland Court of Appeals strongly endorsed the concept of state floodplain regulations, but held that the regulations in this case had been based improperly on data that assumed future "developed" watershed conditions. The statute required consideration only of existing conditions. The court did not invalidate the regulations, but it did require a recalculation of flood elevations. Later the state statute was changed to explicitly permit the consideration of future watershed conditions.

The Minnesota court in County of Ramsey⁶⁷ permitted minor irregularities in statutory procedures. The court held that regulations adopted by the city of Lilydale to qualify for flood insurance, under an order of a lower court to adopt such regulations within 72 hours, were valid despite the failure of the city to provide public notice of the regulations as required by state zoning laws. The regulations were adopted while rising waters threatened to flood the area. The court

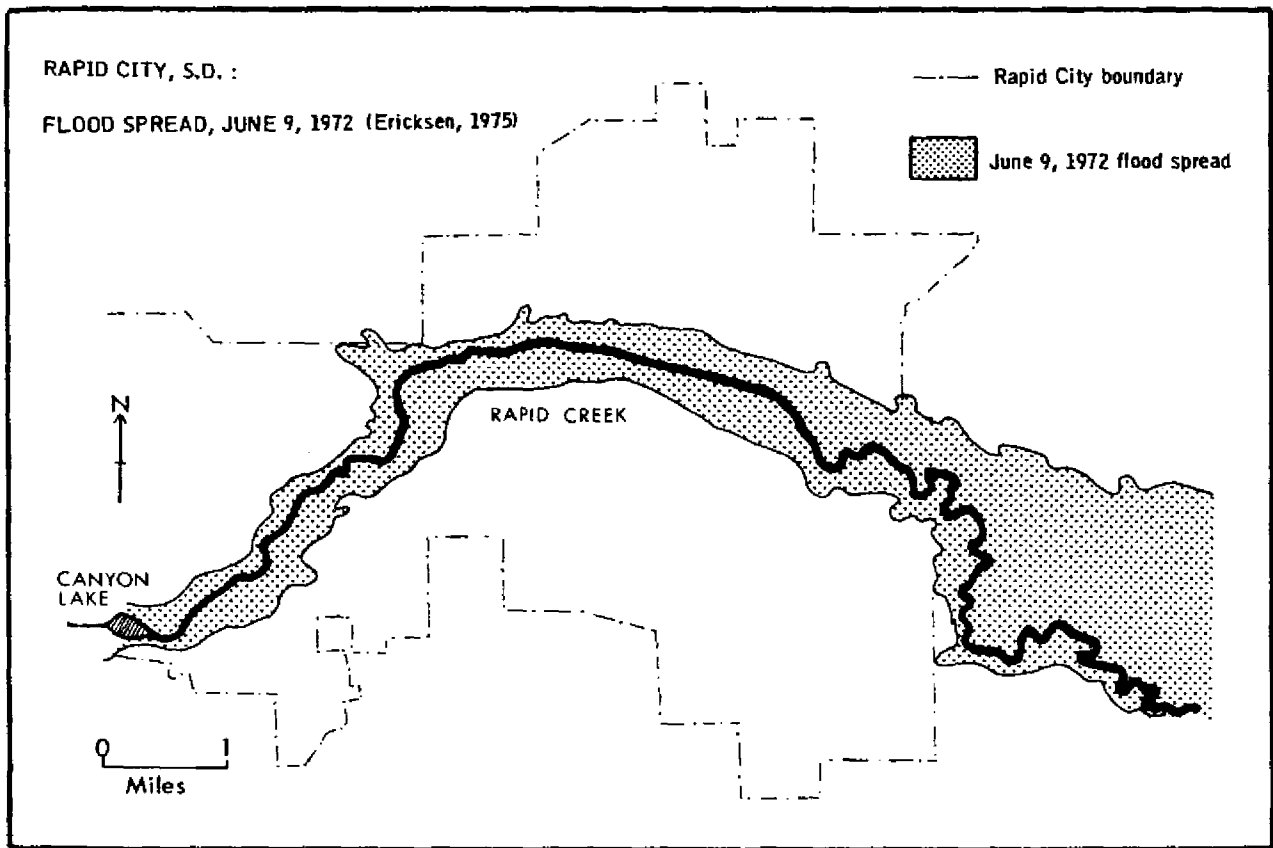
noted that statutory notice and hearing procedures would have been so time-consuming that the flood would have occurred before the regulations were adopted negating, in part, the reason for their adoption. The court stated that failure to comply with statutory procedures could only be justified in emergency circumstances. In addition, the court found no real denial of due process since the landowner contesting the regulations was in fact aware of their impending adoption.

Validity of Interim Regulations

In several cases, landowners challenged interim regulations as not having been specifically authorized or adopted pursuant to statutory procedures. Interim regulations are specifically authorized only in some of the states. There has been some question, therefore, whether such regulations exceed the scope of local powers or fail to follow prescribed procedures. As noted above, an Alabama court held that a resolution intended as an interim regulation was not a valid basis for denying a building permit. Courts in three other decisions supported more formal interim floodplain regulations.

In Cappture Realty Corp.⁶⁸ the Superior Court of New Jersey upheld a moratorium for construction on flood-prone lands until a flood control plan could be prepared. The moratorium had been adopted in October 1971 and extended for yearly periods until November 1974. All statutory procedures had been followed in adopting the ordinance. Under the terms of the ordinance, special permits could be obtained, providing construction did not generate any additional surface runoff. An exception had been denied in the case.

In Lindquist⁶⁹ the South Dakota Supreme Court held that adoption of a resolution by the City Council of Rapid City was a valid exercise of police powers. After the devastating flood of June 12, 1972, the resolution prohibited issuance of building permits for one block on



In Lindquist v. Omaha Realty Inc., the South Dakota Supreme Court upheld a moratorium against rebuilding in this area along Rapid Creek.

Source: Ericksen (1975)

either side of Rapid Creek until a study was completed by the planning commission. The resolution and subsequent "notice of intent to acquire" issued by the city in September 1974 did not take property under eminent domain. The court observed:

This appears to be a legitimate government interest when we consider the situation at the time the resolution was adopted, that is, widespread destruction and a need for some emergency action.⁷⁰

Again, all procedures for adoption of a resolution had apparently been followed.

In Beckendorff v. Harris-Galveston Coastal Subsidence District,⁷¹ the Texas Supreme Court upheld the issuance of temporary groundwater withdrawal permits for an area subject to subsidence-induced coastal flooding until a comprehensive plan could be prepared.

Courts have widely upheld interim resource management regulations in analogous contexts where statutory procedures were followed. These include interim regulations adopted pursuant to the California⁷² and North Carolina⁷³ Coastal Zone Management Acts and interim wetland protection regulations adopted under the New York Coastal Wetlands Protection Act.⁷⁴

Validity of State Floodplain Regulations

All decisions have upheld contested state floodplain regulations as within the scope of statutory powers. The sufficiency of state floodway statutes was sustained by courts in Iowa,⁷⁵ Washington,⁷⁶ Indiana,⁷⁷ and New Jersey.⁷⁸ The Maryland Court of Appeals in A. H. Smith Sand and Gravel Co.⁷⁹ held that the state had sufficient power to adopt state floodplain regulations pursuant to a broad pollution control statute. In State v. Crown Zellerbach Corp.,⁸⁰ a Washington court upheld the power of a state agency to attach conditions to permits for structures in streams in order to ensure compliance with pollution control standards within three years.

Several courts sustained state or state-supervised local regulations against claims that they violated local home rule powers. In Pope,⁸¹ the Georgia Supreme Court held that the Metropolitan River Protection Act was valid and did not violate local home rule powers or constitute state zoning. The act required permits for development in the stream corridor (all land within 2,000 feet of the stream) and the 50-year floodplain to protect the flow of flood waters and prevent erosion, siltation, and water pollution. The court held that flooding was a matter of statewide concern. Similarly, local home rule arguments were rejected in the Washington and Indiana floodway cases.

Courts unanimously upheld other types of state resource management regulations against local home rule arguments including the Oregon State Wild and Scenic River Act,⁸² which requires state permits for uses within the river corridor; the Minnesota State Wild and Scenic River Act⁸³ and state standards adopted for local regulation; the California Coastal Zone Management Act,⁸⁴ which requires permits from regional councils; the New Jersey⁸⁵ and North Carolina⁸⁶ Coastal Zone Management Acts; and New York's regulations for its Adirondack Park.⁸⁷ The reasoning was similar in each case: the matter was of more than local concern. In addition to these cases, a New York court sustained county wetland regulations adopted pursuant to a statute that authorized the county to act if towns failed to pass appropriate ordinances.⁸⁸ A town argued that county regulations for a town without controls violated home rule powers. This argument was rejected, again based on the rationale that wetland protection was of more than local concern.

Adequacy of Regulatory Objectives

Landowners challenged the validity of floodplain management objectives in a few cases. During the decade, courts endorsed six major flood loss reduction goals.

(1) Preventing increases in flood heights and damages. Courts in California,⁸⁹ Indiana,⁹⁰ Iowa,⁹¹ and Washington⁹² strongly endorsed regulations designed to protect flood flow capacity and prevent landowners from increasing flood heights or velocities on other lands. Several of these cases specifically endorsed the consideration in the regulations of cumulative impacts and future development.

(2) Protecting flood storage. The Supreme Court of Minnesota sustained watershed district regulations designed to protect flood storage.⁹³ Similarly, a Massachusetts court sustained regulations to protect storage along the Neponset River, even where there was evidence that a proposed use would have raised flood heights only 1/4 inch.⁹⁴ On the other hand, an Illinois court held that certain storage restrictions that prevented all private use of lands were unreasonable, although it generally endorsed the storage concept.⁹⁵

(3) Protecting buyers from victimization caused by subdivision and sale of flood-prone lands. Illinois,⁹⁶ Missouri,⁹⁷ and New Jersey⁹⁸ courts sustained subdivision regulations requiring storm sewers. The New Jersey court determined that a planning board's decision to approve a plat without taking into account possible problems with drainage was invalid since consideration of drainage was an affirmative duty.⁹⁹

(4) Protecting landowners from flood losses due to their own use of the floodplain. In Turnpike Realty,¹⁰⁰ the Massachusetts Supreme Court endorsed as basic policy "the protection of individuals who might choose, despite the flood dangers, to develop or occupy land on a floodplain."¹⁰¹ A New York court cited and quoted this language and held that "[i]t is beyond question that these objectives which correspond closely to the stated purposes of present ordinance, may be the subject of a legitimate exercise of the police power. . ." ¹⁰²

(5) Protecting and promoting the general welfare, including reduction in public flood-related expenses. The Massachusetts court in Turnpike also strongly endorsed the reduction in public costs. It stated that a principal objective for floodplain regulations was "the protection of the entire community from individual choices of land use which require subsequent public expenditures for public works and disaster relief."¹⁰³ A New York court also endorsed this goal and language.¹⁰⁴

Discrimination

Courts considered arguments that regulations discriminated between similarly situated landowners in several cases. In Beckendorff¹⁰⁵ a Texas court held that interim regulations controlling the withdrawal of ground water to prevent subsidence and flooding were valid and nondiscriminatory despite their application to only two counties. The appellant argued that all landowners who might contribute to the problem should be regulated. Noting the regulations could be expanded in the future to other areas, the court held that "the legislature may implement their programs step by step, adopting regulations that only partially ameliorate a perceived evil and deferring complete elimination of the evil to future regulations."¹⁰⁶ This ruling gives support to community and local efforts to map and regulate the most seriously threatened flood hazard areas first and provide for the gradual inclusion of other areas over time. Regulatory approaches addressing some but not all areas have also been sustained for regulations applying to coastal but not inland wetlands¹⁰⁷ and wetlands in a particular coastal area but not another.¹⁰⁸

Reasonableness of Regulations

In many cases, courts considered the reasonableness of regulations, that is, whether the regulatory standards had some reasonable tendency to accomplish the regulatory goals.

Frequency of flooding. What frequency of flooding should be used to determine floodways or flood fringe elevations? What degree of restriction is justified for particular flood frequencies? The "frequency" question has not been widely litigated, although courts have sustained regulations for particular frequencies of flooding in several cases. The Washington Supreme Court sustained encroachment restrictions for an area identified by the Corps of Engineers and the state as the 100-year floodway.¹⁰⁹ Similar restrictions were sustained for 100-year floodway areas in Indiana¹¹⁰ and Iowa.¹¹¹ The Maryland Supreme Court sustained state regulations for the 50-year floodplain.¹¹² The Rhode Island Supreme Court sustained state permit requirements for activities in wetlands, defined to include the 50-year floodplain.¹¹³

Courts sustained restrictive controls based on historic flood data in a number of cases, although no frequency was assigned to the flooding. In Turner,¹¹⁴ a California court sustained open space zoning for an area devastated by flooding in 1962 and which had been flooded four times since 1936. In Turnpike Realty,¹¹⁵ the Massachusetts Supreme Court sustained open space regulations for an area which had been flooded at least three times since 1936. A New York court upheld a floodplain zoning ordinance which required that the "elevation of the lowest floor to be used for any dwelling purpose in any residential structure shall be equal to or higher than the elevation of the high water level as determined by the enforcement officer in accordance with previous flood records," in Wolfram v. Abbey.¹¹⁶ The court found that the reference in the ordinance to "previous flood records"¹¹⁷ was sufficiently specific since flood records for the subject area had been officially compiled by the Corps of Engineers and the town board had adopted these as part of the town's official floodplain plan.

From these cases it is clear that courts are willing to sustain highly restrictive regulations for frequently flooded areas. Quantified estimates of flooding are desirable but not essential.

Accuracy of mapping. In one case, a Michigan court of appeals held that floodplain regulations were invalid because they were applied to an area where "there was no evidence of flooding."¹¹⁸ But this is the only case that invalidated a floodplain regulation outright for lack of data and the court did so apparently because the regulation was applied to an area without any historical or theoretical evidence of flooding.

On the other hand, the Iowa Supreme Court upheld a state floodplain permit requirement for a property where there were no maps but there was evidence of flooding.¹¹⁹ The Iowa statute required that landowners seek state permits for structures or obstructions in the floodplain but did not require state floodplain mapping. A landowner in this case claimed that he should not have been left to his own devices to determine whether he was in the floodplain. The court disagreed, noting that since the landowner had constructed a levee at the site he must have suspected or known he was in the floodplain.

Map scale apparently has not been litigated, but the issue of minor inaccuracies has been raised. In Turnpike Realty,¹²⁰ the Massachusetts Supreme Court upheld the sufficiency of Dedham's floodplain zoning map which incorrectly included in the floodplain two knolls with a combined area of 3.4 acres. However, for other areas, there was substantial evidence of flooding, including photographs and exhibits of flooding from 1954 and 1967 and testimony of an expert hydrologist. Flood levels had been reached in 1936, 1938, 1955, and 1968. The court held that inclusion of the knolls was "inadvertent."¹²¹ This minor inaccuracy did not invalidate the regulation since the owner could seek a special

permit for such areas under ordinance provisions allowing a landowner to demonstrate that a particular area was not subject to flooding.

In Just,¹²² a Wisconsin court upheld a procedure for remedying map inaccuracies through field inspections and the application of written criteria to the wetlands in question.

Several courts have sustained suspensions of communities from the NFIP because of failure to adopt adequate regulations, despite community arguments that because of map inaccuracies they should not be required to adopt them. In Roberts v. Secretary, Department of Housing and Urban Development,¹²³ a federal district court granted summary judgment for FIA, sustaining flood boundary maps and subsequent regulations based on them. The floodway and floodplain areas had been mapped according to present and historical conditions rather than conditions expected to exist after completion of a flood control project and other public works. The community argued that future conditions should be considered.

In a second case, Town of Falmouth v. Hunter,¹²⁴ a federal district court similarly ruled that Falmouth, Massachusetts could be suspended from participation in the flood insurance program. The town claimed that coastal maps included in the flood insurance study were inaccurate. Falmouth had entered the emergency program in 1971. The Corps of Engineers completed the flood insurance study in 1972 and the town entered the regular program in 1973. In 1974 the town appealed the flood insurance study, claiming that boundaries were arbitrary and unsupported by sound data and scientific principles. FIA conceded some errors, made modifications, and issued revised elevations in 1975. New elevations went into effect in April 1976. The town proposed an alternative method for determining elevations and requested six months to carry out studies applying the new approach. FIA rejected this proposal and began action to suspend the town's participation in the NFIP. The town initiated a

suit to prevent suspension. The court sustained the suspension, reasoning that the community could adopt the required regulations while it was carrying out its own studies.

Standards for floodway areas. In several decisions courts sustained criteria used for defining floodway areas. In Young Plumbing and Heating Co.,¹²⁵ the Iowa Supreme Court upheld the Iowa Natural Resources Council's denial of a permit for a condominium within a 100-year floodway which was 200 feet wide. The condominium would have increased flooding by .3 of a foot, but the cumulative impact (assuming an equal degree of encroachment) would have been 1.7 feet. The court ordered that the building be removed, despite arguments by the landowner that he should be allowed to channel the stream to provide compensatory increases in flow capacity.

In Krahl,¹²⁶ the Minnesota Supreme Court sustained a water district's regulations based on a concept of floodway delineation which involved permitting encroachments to extend "approximately 20% of the distance between the flood zone contour and the creek channel."

In Subaru of New England,¹²⁷ a Massachusetts court sustained the town's highly restrictive floodplain regulations which were designed to protect natural valley storage of the Neponset River. The court sustained the regulations despite evidence that the proposed development would raise flood heights only 1/4 inch.

Cumulative impacts. Several courts sustained state and local consideration of the "cumulative impact" of development in evaluating development proposals or determining encroachment lines. In the Young¹²⁸ decision the Iowa Supreme Court sustained consideration of cumulative impacts. The Georgia Supreme Court in Pope,¹²⁹ endorsed consideration of cumulative impacts even though the court found insufficient evidence of cumulative impact in this instance. In Subaru of New England,¹³⁰ a

Massachusetts court, in upholding restrictions, strongly endorsed a cumulative impact argument. In Beckendorff,¹³¹ the Texas Supreme Court held that regulation of individual groundwater extractions to prevent cumulative subsidence and flooding effects was justified. It noted:

An individual's action may be lawfully regulated when it operates in concert with others' actions to produce an effect, even though the individual action of itself would be incapable of achieving the effect.¹³²

Despite judicial approval for consideration of cumulative impacts, several courts held that in specific factual situations, evidence of cumulative impacts was insufficient to justify withholding a permit. These include a Massachusetts coastal wetlands case¹³³ in which it was argued that filling would have detrimental impact on flooding and erosion but little evidence was provided to support this conclusion; Pope,¹³⁴ in which generalized testimony on the impact of impervious surface was held insufficient to justify denial of a permit for a tennis court; and a New Jersey case in which the court held that a 2-acre minimum lot size throughout the town to reduce runoff and increase infiltration was not justified by the evidence.¹³⁵

Consideration of Present Versus Future Conditions. Several courts considered the sufficiency of flood maps based on existing versus projected watershed conditions.

In A. H. Smith Sand and Gravel Co.¹³⁶ a Maryland court sustained state floodplain regulations, but held that flood maps were to be based on existing rather than future watershed conditions and ordered the modification of flood boundaries. The enabling statute required that existing conditions be considered. The Maryland legislature later amended the statute to authorize mapping based on future watershed conditions.

As noted above, a federal district court in Roberts¹³⁷ sustained the suspension of a community from the NFIP for failure to adopt "regular program" regulations, despite a claim by the community that the flood maps

were inadequate. This case sustained federal mapping of floodplains based on existing conditions. However, the court might also have sustained maps based upon future conditions had FIA taken this approach.

In Young Plumbing and Heating Co.,¹³⁸ discussed above, the Iowa Supreme Court strongly endorsed efforts of the Iowa Natural Resources Council to take into account anticipated future development in determining encroachment limits. With regard to the argument that damages to adjacent landowners were "anticipatory," the court held that the Council had properly looked to the future:

One function of the Council is to facilitate flood control through planning. . . . Part of this function involves projecting the occurrence of floods. In this sense the actions of the Council are always anticipatory as to floods, the effect of channel modifications on adjacent lands, and future development on adjacent lands. Regardless of whether like construction or development were to be undertaken on the opposite bank, the proposed construction and the accompanying channel modifications will reduce the number of potential uses and the corresponding value of the adjacent land due to increased susceptibility to flooding. The effect on adjacent lands being a consideration mandated by the legislature, and planning being a delegated function of the Council, the anticipatory nature of the Council's findings does not work against their reasonableness.¹³⁹

Similarly, in Pope¹⁴⁰ it was held that under the Georgia River Protection Act, the metropolitan council could take into account future conditions.

Judicial review of reasonableness. Courts deferred to legislative or agency determinations on factual matters¹⁴¹ if there was any evidence to support them. Judicial deference to agency fact-finding is due in part to courts' reluctance to act as experts and in part to their endorsement of the separation of judicial, legislative, and executive powers.

Iowa's Young¹⁴² decision represents the most common judicial approach for review of federal, state, and local agency decisions, including data gathering and analysis and the selection of data-gathering and analysis techniques. Here the court held that an agency decision will be reversed only where it is "unsupported by substantial evidence in

the record made before the agency when the record is viewed as a whole."¹⁴³

(emphasis added). The court applied the following standard of review to determine whether there was substantial evidence:

Evidence is substantial when a reasonable mind would accept it as adequate to reach a conclusion [T]he entire record must be considered in determining whether the challenged finding has sufficient support. Nonetheless, the possibility of drawing two inconsistent conclusions from the evidence does not prevent an administrative agency's findings from being supported by substantial evidence¹⁴⁴

Finding a basis for the Iowa Natural Resources Council's conclusions in the record and stressing the impact of the proposed use on adjacent lands, the court upheld the Council. The court further noted:

The conclusion of the Council is further supported by the deference with which a reviewing court should approach agency action due to the Council's particular expertise Still a court reviewing agency action must scrutinize the whole record to evaluate any alleged statutory grounds for invalidation.¹⁴⁵

Judicial support for decision making by special agencies or boards occurred in many cases.¹⁴⁶ California¹⁴⁷ and Massachusetts¹⁴⁸ courts gave particular deference to local decision making.

However, as noted above, several courts held that agency decisions in specific contexts were not based on sufficient data.¹⁴⁹ In requiring the upgrading of flood maps after new flood data became available, the Maryland court noted that "[t]he conclusion reached by an administrative agency, with all of its expertise, can be no more sound than the factual basis upon which it rests."¹⁵⁰

Special Exceptions and Variances

Courts widely sustained special permit approaches, which were often applied to floodways or river corridors.¹⁵¹ In Pope,¹⁵² the Georgia Supreme Court upheld the Metropolitan River Protection Act's requirement that permits be sought for development within 2,000 feet of streams. This act more specifically provided that uses within 150 feet of the

river and the 50-year floodplain were restricted to those "not harmful to the water and land resources of the stream corridor . . . [which do not] significantly impede the natural flow of flood waters, and [which] will not result in significant land erosion, stream bank erosion, siltation or water pollution."¹⁵³ Grading and vegetation clearance permits were required; cut and fill operations that would alter the natural flow of waters were prohibited; and only 20% of the floodplain could be covered with impervious surfaces.

Several courts deemed that the potential for issuance of a special permit was significant in deciding whether regulations were a taking of private property. These decisions included a landmark Wisconsin wetland protection decision,¹⁵⁴ a Washington Supreme Court decision sustaining encroachment regulations¹⁵⁵ and a Massachusetts Supreme Court decision supporting the validity of local restrictions for a floodplain area.¹⁵⁶

Courts sustained the adequacy of standards for special permits in all cases addressing the issue. In Dur-Bar Realty Co.¹⁵⁷ a New York court held valid an ordinance that permitted no floodplain uses by right and required a local board to evaluate proposed uses to determine their impact on flood heights and safety from flooding.

In Wolfram,¹⁵⁸ a New York court upheld a floodplain zoning ordinance that authorized the zoning administrator to determine flood hazard areas with data from the Corps. Special permits were to be obtained from the zoning board of appeals, which was also authorized to require "[a]ny other controls or restrictions which are deemed necessary to minimize or eliminate damage to buildings and structures from flood waters."¹⁵⁹

Data base for permit approval or denial. Several courts held that permits were invalidly denied in particular circumstances because of an insufficient factual basis for such denial. In MacGibbon v. Board of Appeals,¹⁶⁰ the Massachusetts Supreme Court held that a permit for fill

in a coastal wetland had been invalidly denied on flooding and erosion grounds, both because there was lack of evidence of such problems and because adequate measures could be taken to deal with flooding and erosion.

In Pope,¹⁶¹ denial of a permit for a tennis court based on an argument of cumulative effect on flooding was not supported by sufficient evidence. The landowner introduced evidence from the director of Atlanta's Bureau of Buildings that construction of the tennis court would not significantly affect the river. The only rebuttal was testimony of an environmental planner with the Atlanta Regional Commission who had never inspected the proposed construction site.

Several courts upheld the denial of variances for floodplain areas. In Kraiser v. Zoning Hearing Board,¹⁶² a Pennsylvania court sustained denial of a variance for a residential duplex in a floodplain conservation area. The court noted that, based on engineering testimony, "it can be properly concluded that building on the floodplain would increase flood height and conceivably increase the hazard to the inhabitants of other buildings both on and away from the zoned areas."¹⁶³

The court also noted, "Kraiser's puzzlement is understandable. If he complies with the permitted conditional uses under the Floodplain Ordinance he finds himself for all practical purposes stuck with a useless property. But in the interests of all the residents, he must suffer along with other property owners who are likewise affected by the ordinance."¹⁶⁴

Similarly, in National Merritt, Inc. v. Weist¹⁶⁵ the New York Court of Appeals held that a zoning board of adjustment properly denied a property owner's request for an area variance for a 19 3/4-acre parcel to be used as a shopping center. The decision was due in part to a

finding that the shopping center would create flooding and drainage problems for the area. The court noted:

Considerable evidence, also unrebutted, was introduced to demonstrate that the leveling of the property and its conversion into an area almost completely covered by structures and asphalt pavement would result in severe flooding and drainage problems Both the United States Department of Agriculture and the Westchester County Soil and Conservation Service advised the parties that petitioner's plans did not adequately provide for the control of storm water and erosion.¹⁶⁶

In contrast, one court held that a variance for a liquid propane gas tank was acceptable in a wetland area subject to flooding where there was no evidence of adverse impacts.¹⁶⁷

In Green's Bottom Sportsmen, Inc. v. St. Charles County Board of Adjustment,¹⁶⁸ a Missouri court held that a zoning board of adjustment could revoke a permit that was incorrectly issued by a zoning commission. The permit was for a gun club on a 49-acre tract of floodplain near the Missouri River where county floodplain regulations did not permit such uses. Nearby landowners appealed the permit to the board several months after the commission issued it. Prior to this they had been unaware of the club.

The Taking Issue

In 36 of the 55 floodplain regulation cases in the last decade, a "taking" was one of the issues addressed. The courts in 34 of these cases held that there had been no taking. A taking was found in each of two cases where the regulations were subject to other deficiencies such as inadequate data.¹⁶⁹ Both were lower court decisions; in each, the court endorsed the general concept of regulations yet disapproved of them as applied to the specific property in question. This resounding support for floodplain, wetland, coastal zone, and other regulations against claims of taking may explain why courts now focus more closely on the reasonableness issue and other aspects of regulations and why "taking" is now rarely the major issue.

U.S. Supreme Court Cases. During the 1970s the U.S. Supreme Court considered the taking issue in zoning cases for the first time since the 1920s. One case involved regulations for a flood area although the court did not make a decision on the merits. Because U.S. Supreme Court decisions are important to all lower courts, its treatment of the taking issue will be examined.

In the first of these cases, Penn Central Transportation Co. v. City of New York,¹⁷⁰ the Court upheld New York City's Landmarks Preservation Law to protect landmarks and neighborhoods. This law, combined with applicable zoning ordinances, permitted that individual structures be designated as "landmarks" and the blocks containing the structures as "sites". Owners of designated structures were required to keep exterior features in good repair. Exterior alterations require approval by a commission. Accompanying zoning bylaws permitted owners of designated buildings to transfer development rights to other lots on the block.

In analyzing the law, the Court noted that "this Court, quite simply, has been unable to develop any set formula for determining when justice and fairness require that economic injuries caused by public action be compensated by government, rather than remain disproportionately concentrated on a few persons."¹⁷¹ The Court analyzed the public need for the law and the severity of the impact on Penn Central, the landowner. It found that Penn Central had not been unfairly burdened by the regulations, which affected all landmarked property. The Court concluded that Penn Central had a reasonable return on its investment in light of the use now being made of the structure and similar uses in the area owned by Penn Central. Although the Court did not consider the constitutionality of the development rights scheme per se, it noted that the rights "were valuable" and served to mitigate the impact of the regulations.

In a second case, Agins v. City of Tiburon,¹⁷² the Court generally sustained "residential planned development and open space" zoning regulations for a section of Tiburon, California. The regulations had been adopted pursuant to a state law that required California communities to prepare a plan governing both land use and development of open space. The contested regulations were designed to discourage the "premature and unnecessary conversion of open-space land to urban uses." One of the ordinance's objectives was to prevent premature conversion of open space, "thereby protecting against the resultant adverse impacts such as . . . disturbance of the ecology and the environment, hazards related to geology, fire and flood. . . ."¹⁷³ The Court did not extensively discuss the taking issue since the landowner had not applied for a permit under the ordinance, but had rather attacked the general validity of the regulations. The Court strongly endorsed the regulatory objectives--to discourage premature conversion of open space. It held that the landowner had not shown that he was deprived of economic use of his land. Noting that benefits as well as burdens from the regulations would accrue to the landowner and that this was relevant to a consideration of taking, the Court noted:

Appellants therefore will share with other owners the benefits and burdens of the city's exercise of police power. In assessing the fairness of the zoning ordinance, those benefits must be considered along with any diminution in market value that the appellants might suffer.¹⁷⁴

The Court here, as in Penn Central, did not concentrate on the diminution in value caused by the regulations but on whether some value remained for the entire parcel of land.

In a third decision, San Diego Gas and Electric Co. v. City of San Diego,¹⁷⁵ the Supreme Court dismissed an appeal by a utility company which claimed that "downzoning" of a 214-acre tract (some of it floodplain) by the city of San Diego was a taking by inverse condemnation.

The Court dismissed the appeal because a final judgment had not been made in the case since further proceedings were contemplated at the trial court level. Nevertheless, Justice Brennan filed a vigorous dissent joined by Justices Stewart, Marshall, and Powell.

The decision is of interest despite dismissal of the appeal because the strong dissent indicates a potential willingness on the part of the Court to review state and local land use regulation cases as violative of 5th Amendment as well as 14th Amendment guarantees. However, it is to be noted that regulations were apparently being used to lower land values prior to acquisition--a traditionally invalid use of police powers.

The appellant in the case had acquired 214 acres of marshy flood-plain land in 1966 when it was zoned for industrial and agricultural uses. In 1973, San Diego downzoned a portion of the land from industrial to agricultural and increased the minimum lot sizes. The city also incorporated the land into an open space plan and designated it for potential acquisition. The appellant filed suit, claiming damages of \$6,150,000 in inverse condemnation, and seeking mandamus and declaratory relief as well. The trial court granted judgment for the appellant. The California Court of Appeals affirmed, holding, in part, that the purpose of the downzoning was to lower property values. The California Supreme Court granted the city's petition for hearing but transferred the case to the Court of Appeals for rehearing in light of the intervening Agin decision. There, the California Supreme Court had held that an owner deprived of substantially all beneficial use of the land by zoning regulation is not entitled to an award of damages in inverse condemnation, but only to invalidation of the regulation in an action for mandamus or declaratory relief. The California Supreme Court denied further review and the matter was appealed to the U.S. Supreme Court.

Justice Blackmun, speaking for the majority of the Supreme Court, dismissed the appeal because the lower court's decision was not final, but he warned that "we are frank to say that the federal constitutional aspects of that [the taking] issue are not to be cast aside lightly. . ."¹⁷⁶ Justice Brennan, in his dissent, argued that the decision by the California Court of Appeals holding that a state regulation could not be a taking under federal law was a final judgment on this matter, subject to Supreme Court review. He argued further that the Court of Appeals had applied a misinterpretation of federal law and that "once a court finds a police power regulation has effected a 'taking' the government entity must pay just compensation for the period commencing on the date the regulation first effected the 'taking', and ending on the date the government entity chooses to rescind or otherwise amend the regulation."¹⁷⁷

Tests for a taking. Federal and state court decisions during the decade emphasized similar factors in deciding whether a taking had occurred. Several tests were often simultaneously applied. The taking issue was not usually addressed in isolation but in combination with questions about the validity of the regulatory objectives, the reasonableness, basic fairness (due process) and nondiscriminatory nature of the regulations.¹⁷⁸ Regulations that were deficient in other aspects were in several instances held to be a taking.¹⁷⁹ The usual final test was, Did the regulations prevent all economic or reasonable use of the land? The entire parcel was generally examined, not just the area subject to flooding.¹⁸⁰ Regulations which confined property to open space uses were sustained in a number of important decisions.¹⁸¹

Preventing nuisances--Without exception, courts held that prevention of nuisances on private lands was not a taking. Regulations controlling uses that would be "nuisance like" in causing damage to

adjacent lands or threatening public safety do not take any property right because landowners have no right to make nuisances of themselves. During the 1970s many cases upheld floodway and other regulations designed to prevent offsite nuisance-like effects even when those regulations prohibited all or essentially all economic use of lands.¹⁸²

Physical interference with private lands--In contrast with the decisions on nuisance prevention, courts have almost always held that public activities which physically interfere with private lands constitute a taking. For example, public construction of a dune on private land which had been damaged by a severe storm in March 1962, was held to be a taking.¹⁸³ But several courts held that because regulations do not physically interfere with private lands, they do not constitute takings.¹⁸⁴

"Public use" of private land--Courts have usually held that natural conveyance of flood flows, flood storage, erosion control, and other passive flood hazard reduction functions are not public uses of private land that require compensation.¹⁸⁵ As one court in a floodplain case noted, "[T]he State has not placed appellant's land in the path of floods, nature has."¹⁸⁶ Floodplain regulations do not enhance any government enterprise.¹⁸⁷

Balancing private and public interests--Courts generally have balanced society's need for regulations against the impact of regulations on private landowners: severe impact on individual property owners can be justified when the public need is great. In recent years courts have come to rely increasingly on the legislative process to balance the needs and impacts and have minimized judicial oversight.¹⁸⁸

Equity in the distribution of benefits and burdens--Courts noted that government actions which "unfairly" burden a few for the good of the many may be held a taking, although during the decade no floodplain regulations were held invalid on equitable grounds alone. Two Supreme

Court decisions cited above and many lower court decisions on takings have stressed the need for equity in regulations.¹⁸⁹ However, a Massachusetts decision¹⁹⁰ upheld regulations for a wetland flood storage area to prevent increased downstream flood losses despite arguments that regulations benefited downstream property owners without reciprocal benefits to upstream owners. The court held that "as long as the restrictions are reasonably related to the implementation of a policy. . . expected to produce a widespread public benefit and applicable to all similarly situated property," they need not produce a reciprocal benefit.¹⁹¹

Regulations adopted to serve regional, statewide, or national needs and which apply uniformly to flood-prone properties are less likely to be held a taking. In finding that no taking had occurred, several courts emphasized the role of regulations as part of a broader plan or program.¹⁹²

Diminution in value--Courts held that regulations may diminish property values, but that at some point such diminution will constitute a taking. This test has been cited in many cases during the last decade, but rarely has it been more than one of several factors considered.¹⁹³ Instead, courts have paid more attention to whether the regulations deny all reasonable use of the land.

Denial of all reasonable or economic use of land--The most common "final" test for taking during the decade was whether regulations denied all "reasonable" or "economic" use of land. A detailed economic analysis was rarely undertaken. In a number of cases, courts have found that agriculture, forestry, and other open space uses were "reasonable" in certain contexts.¹⁹⁴ Courts also held that the regulation's impact on an individual's entire property, not just the floodplain portion, must be considered in deciding whether reasonable uses remain.¹⁹⁵ Although

courts emphasized, as a matter of principle, that regulations must not prohibit all reasonable use, in several cases they held that proposed uses that would increase flood heights or would be subject to severe flood damages were not reasonable, despite few remaining economic uses for the land.¹⁹⁶

No right to destroy the natural suitability of the land--Several courts held that landowners had no right to destroy the natural suitability or capability of lands. Hence, prohibition of uses threatening such suitability was not considered a taking. In one wetland case,¹⁹⁷ the court sustained the constitutionality of state-supervised shoreland regulations. The decision was based in part on the public trust in waters and also on the theory that a landowner has no right to destroy the natural suitability of the land when such uses will injure the public: no right was "taken" by the regulations. In effect, paramount public interests were recognized in private wetlands.

Wetland and other resource protection regulations. Restrictive wetland regulations have been widely litigated over the last decade, primarily on the taking issue. Most courts have sustained restrictive regulations, particularly in the last five years.¹⁹⁸ Before 1970, most decisions were adverse to highly restrictive wetland regulations, giving rise to the caveats in Volumes 1 and 2¹⁹⁹ that careful distinctions be drawn between floodplain regulations related to hazard reduction and wetland controls designed to protect wildlife and environmental resources. Continued distinction between hazard reduction and environmental regulations may be desirable in some instances to provide independent but interrelated bases for permit evaluation and support for regulations. However, regulations combined to reduce flood losses and protect wetlands may be mutually supportive in a legal context.

Decisions favorable to wetland protection include federal court cases sustaining Corps denials of Section 10 and Section 404 permits for dredging and filling in wetlands because the material could adversely affect wildlife, water quality, and other environmental values. For example, in Deltona Corp. v. United States,²⁰⁰ the U.S. Court of Claims held that the denial of a permit by the Corps of Engineers to dredge and fill a mangrove wetland in Florida did not take private property. The court noted that denial of the permit would affect the usefulness of only a portion of the property.

State court decisions have been increasingly favorable as well. In Just,²⁰¹ the most famous of these, the Wisconsin Supreme Court flatly rejected earlier precedents from other jurisdictions that invalidated wetland controls and it upheld state-supervised county shoreland zoning restrictions as nonconfiscatory. Tight restrictions were not a taking, the court argued, because the landowner had no absolute right to improve the land:

Is the ownership of a parcel of land so absolute that man can change its nature to suit any of his purposes? The great forests of our state were stripped on the theory man's ownership was unlimited. But in forestry, the land at least was used naturally, only the natural fruit of the land (the trees) were taken. The despoilage was in failure to look to the future and provide for the restoration of the land. An owner of land has no absolute and unlimited right to change the essential character of his land so as to use it for a purpose for which it was unsuited in its natural state and which injures the rights of others.²⁰²

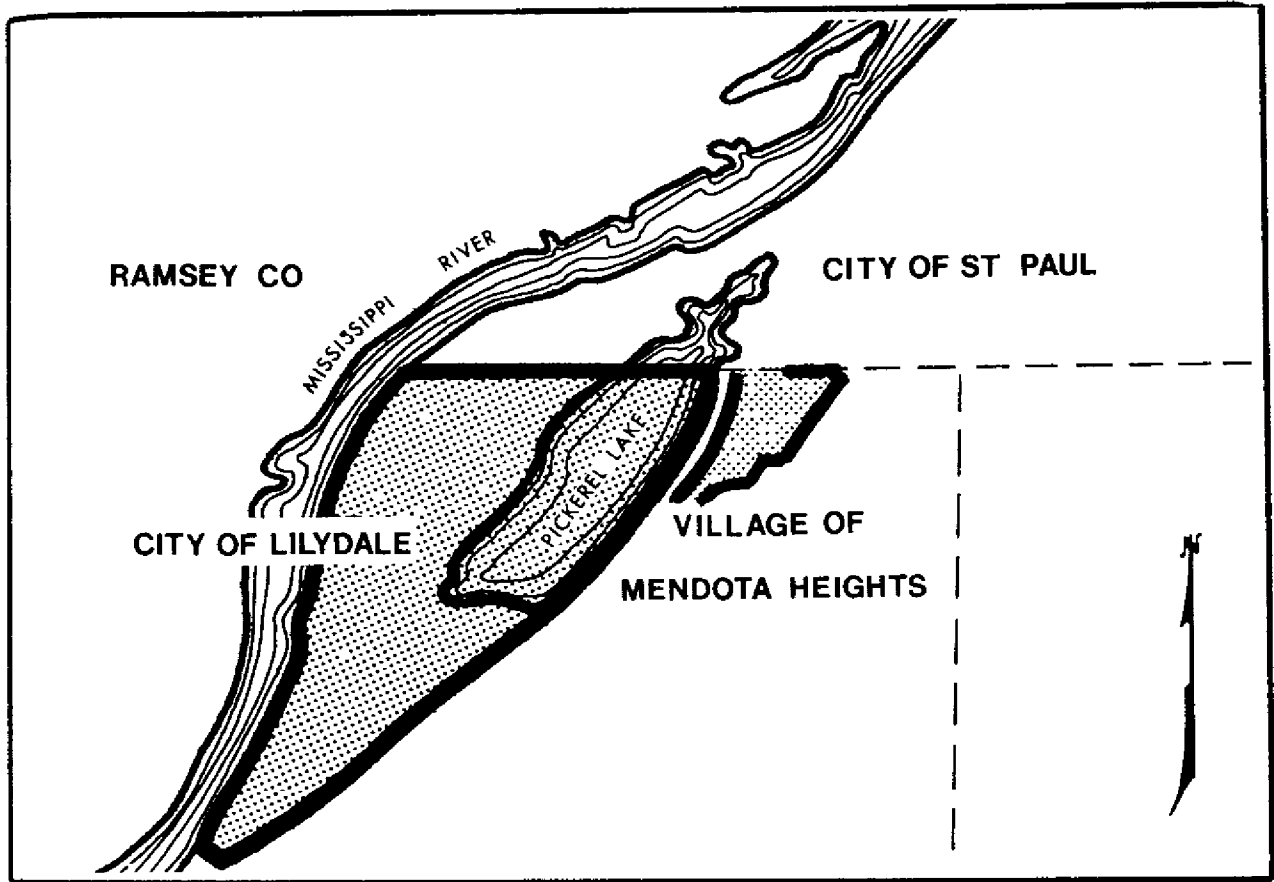
In Potomac Sand and Gravel Co.,²⁰³ the Maryland Court of Appeals upheld a statute prohibiting dredging of coastal wetlands in Charles County. In Sands Point Harbor, Inc. v. Sullivan,²⁰⁴ the New Jersey Supreme Court held that the New Jersey Coastal Wetland Act and an administrative order adopted pursuant to it served valid objectives, did not discriminate between similarly situated landowners, and did not take private property.

Courts have broadly endorsed a wide range of other resource protection and management regulations that apply, to a greater or lesser extent, to floodplains. Courts in Minnesota²⁰⁵ and Oregon²⁰⁶ have sustained special state or state-supervised regulations for recreational wild and scenic rivers or river corridors. Courts in California,²⁰⁷ New Jersey,²⁰⁸ and North Carolina²⁰⁹ have sustained coastal zone management programs. Courts in many states have sustained agricultural zoning.²¹⁰ The courts of Wisconsin²¹¹ and Washington State²¹² have sustained shore-land regulations for lake and stream shores.

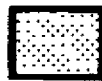
Relationship of regulations to acquisition. In several decisions, courts have considered the validity of floodplain regulations where public purchase of land was contemplated in the future. In County of Ramsey,²¹³ the Minnesota Supreme Court sustained floodplain regulations for severely flooded land intended for future park acquisition. The court held that minimization of flood damages and purchase of flood insurance were valid independent objectives, but warned that regulations designed solely to reduce property values would be a taking. Courts from other jurisdictions have endorsed a similar rule.²¹⁴ Zoning or other regulations (except official mapping of streets) solely to reduce future condemnation costs are a taking, but not regulations based on valid independent objectives that reduce land values only incidentally.

In Turner,²¹⁵ a California court sustained highly restrictive regulations in an area for which the Corps of Engineers had recommended acquisition of flowage easements. The court rejected arguments that payment should be provided for the restrictions and noted that it was the option of the government body to regulate rather than to acquire the lands.

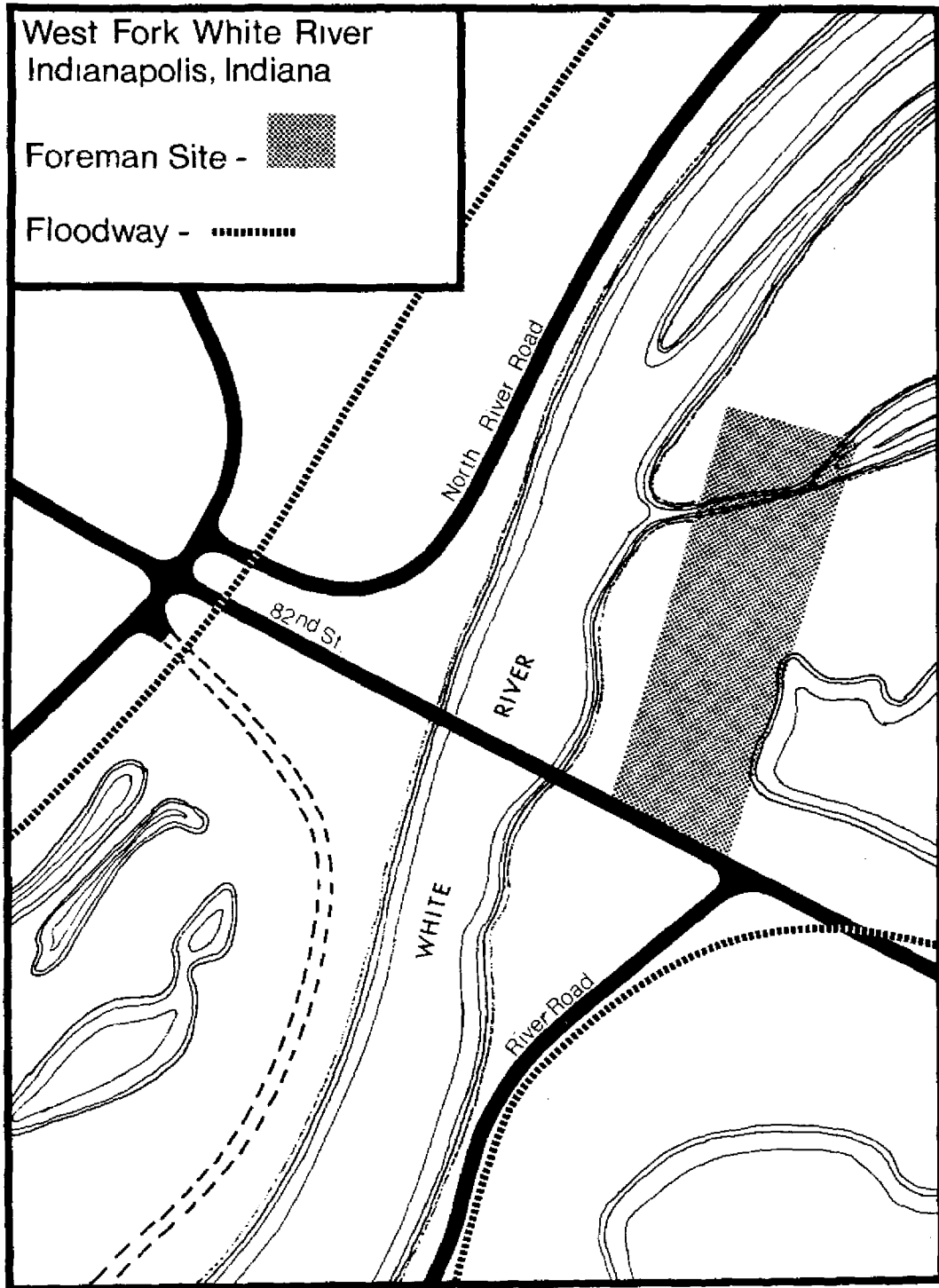
In Foreman²¹⁶ a floodplain landowner questioned the validity of state encroachment regulations based in part on an argument that flood



Lilydale Relocation Project



The Minnesota Supreme Court in County of Ramsey v. Stevens upheld floodplain zoning as applied to this relocation area.



In Foreman v. State Department of Natural Resources, an Indiana court upheld the state's encroachment regulations.

easements should have been acquired instead because the state encroachment statute authorized both regulations and easements. The court rejected the landowner's contention and held that the state had the option either to regulate or to acquire the lands.

In both the Turner and Foreman cases, the landowners argued either that the regulations were invalid as a taking or that payments should be awarded for reduction in land values if the regulations were found valid (i.e., inverse condemnation). These arguments were rejected there and also in Zisk v. City of Roseville,²¹⁷ in which a California court held that a landowner could not claim compensation for floodplain restrictions while at the same time contesting the restrictions. Rather, he should have initiated a suit in eminent domain. A Pennsylvania case took a similar position.²¹⁸ Although no court awarded damages for floodplain restrictions, a Minnesota court warned that damages might be awarded in a case where the impact of regulations was too great.²¹⁹

A New York court held that floodplain regulations with the ulterior motive of maintaining private land as a park were a taking where the owner offered to comply with applicable floodplain regulations.²²⁰ The floodplain regulations were not, in themselves, an issue.

Cases invalidating regulations as a taking. Only two cases in the decade held that floodplain regulations were a taking. Both occurred in the early 1970s and were lower state court decisions. In both instances, the regulations were subject to other defects.

In Sturdy Homes, Inc. v. Township of Redford,²²¹ a Michigan court held that regulations were confiscatory when they were applied to an area with "no evidence of flooding." In American National Bank and Trust Co. of Chicago v. Village of Winfield,²²² an Illinois court generally supported the concept of regulation to protect aquifer recharge, flood storage, and open space, but it stated that restriction of a 32-acre

parcel (70% within the floodplain) to single-family residences was unreasonable. Fill for such residences would have cost \$4,192 to \$12,577 an acre. The land was only worth \$6,000 an acre for single-family use.

A lower court case from New York also held that denial of a permit under a dune protection ordinance (not a floodplain ordinance per se) was invalid, although the regulations were not, per se, a taking.²²³ The irregular procedures followed by the town may have had much to do with the holding, however. The town board had first issued a permit for a dwelling on a dune and then denied it pursuant to a dune protection ordinance. Construction had already commenced after revocation of the permit.

Governmental Liability for Flood Damages

Courts traditionally have not held federal, state, or local governments liable for flood damage except where land has been permanently flooded because of dam construction or other government projects. However, this position has changed as Congress and state legislatures have made units of government responsible for some types of flood damages. For example, in adopting the NFIP, Congress has made the federal government responsible for payment of flood insurance claims. Based on common law theories of liability, courts have also been willing to hold governments liable for certain types of flood damages that result from construction of drainage facilities.

Liability for flood control and drainage measures. Courts have held that governments have no affirmative duty to construct flood control works and are not responsible for flood damages if dams, levees, or other protection works fail to provide flood protection.²²⁴ This is generally true even if the works were operated negligently.²²⁵ However, courts have found liability in certain circumstances. For example, a

court held a government body liable for construction of a dam that caused flooding which was "natural and probable," even though not intended, because the dam increased groundwater levels.²²⁶

In some jurisdictions, courts have held governments liable for construction of storm sewers that increased flooding on downstream land. For example, in Masley v. City of Lorain,²²⁷ the Ohio Supreme Court held that the development of a portion of a creek as a stormwater system that increased flooding was a taking of property. Courts have also held municipalities liable for flood damages resulting from improperly designed storm sewer systems constructed by landowners and dedicated to the city.²²⁸

Liability for adoption of regulations. No court has held a government responsible for increased flood damages caused by adoption of regulations or failure to adopt regulations. Whether such a holding will occur at some time in the future in light of courts' liberalized positions on government responsibility remains to be seen. The court in Turner²²⁹ hinted that a government unit might be liable for increased flood damages if regulations substantially increased damages beyond those naturally occurring. In addition, the Minnesota Supreme Court in County of Ramsey²³⁰ held that a community must adopt floodplain regulations pursuant to a state statute specifically requiring such adoption. Moreover, the court specifically ordered a noncomplying community to adopt regulations within 72 hours, although it stopped short of holding that financial liability would accrue from failure to do so. Even if a government unit was responsible, individual government officials would not be. In Gaebel v. Thornbury,²³¹ a Pennsylvania court held that individual council members were not personally responsible for the decrease in value caused by regulations.

Flood insurance payments. At least 25 cases have addressed some aspect of the National Flood Insurance Program. Although none has focused specifically on NFIP standards for floodplain regulations, the cases will be discussed briefly because the program is pertinent to state and local regulations.

In the best known of these cases, Texas Landowners Rights Association v. Harris,²³² a group of landowners and municipalities attacked the basic validity of the statutory framework of the NFIP pursuant to which FEMA establishes land use control standards as a condition to purchase of federally subsidized flood insurance. The District Court for the District of Columbia upheld the program and its regulations and issued a declaratory judgment, reasoning that subsidized flood insurance was a benefit and not a property right. A community could not claim a taking of property if insurance (benefits) or disaster relief (benefits) were denied for failure to comply with standards. The court also rejected arguments that the program violated the 10th Amendment by legislating matters exclusively within the prerogative of the states.

Although this was a lower federal court decision and, as such, does not act as a bar to later cases contesting particular aspects of the NFIP, it gives considerable support to the program's basic validity.

In another important decision, Commonwealth of Pennsylvania v. National Association of Flood Insurers,²³³ a federal district court in Pennsylvania rejected a billion dollar claim against FIA by the Commonwealth of Pennsylvania after Hurricane Agnes. Pennsylvania argued that FIA had not publicized the National Flood Insurance Program, as required by statute. The court held that FIA had distributed brochures and carried out other public information activities.

Two federal court decisions sustained FIA suspension of communities from the NFIP because they failed to adopt "regular" program regulations.

In both cases the community contested the accuracy of the flood maps prepared by FIA. In one, Roberts v. Secretary, Department of Housing and Urban Development,²³⁴ the district court held that maps taking into account existing conditions were sufficient. In the second, City of Falmouth,²³⁵ the district court noted that the normal map appeal procedure had been followed and that if a community wanted further review, it could adopt the necessary ordinances required for the regular program while additional analysis was taking place.

Other decisions have addressed the payment of flood insurance claims. One court denied a claim for damage to construction materials placed on the ground without cover and damaged by flooding from Lake Erie.²³⁶ Another court held that under the terms of the statute and insurance policies, a rug damaged when a patio was flooded was not "flood damage" compensable under the flood insurance act.²³⁷ Similarly, another court held that damage to a house from gradual beach erosion not associated with severe storms was not compensable.²³⁸ In contrast, one court held that damage to a slab foundation and patio for a beachfront cottage undermined by a hurricane was compensable because it was due primarily to a single severe event.²³⁹

Another court decided that damage to houses built on filled wetlands in Louisiana,²⁴⁰ which was caused by flood-related soil compaction, was not compensable even though flooding in the area did increase groundwater levels.

Courts in several cases denied claims where insurance was purchased while a flood was in progress or on the day of the flood.²⁴¹ One court held that a private insurance company had to pay an insurance claim for damage to a property in a community not in the NFIP.²⁴² An insurance agent erroneously accepted a check for a flood insurance policy, submitted

an application form, and cashed the check before learning that flood insurance was not available.

One court upheld total loss payments for a partially damaged structure because repair would have been impractical. In this case, Gibson v. Secretary of U.S. Dept. of Housing and Urban Development,²⁴³ a district court held that landowners were entitled to recover costs for constructing a residence at a new location, despite the physical possibility of repairing the structure at the existing location at a much lower price. Flooding had created a permanent channel around the west side of a house, separating it from the stream bank and increasing the flood risk to the point that repair was impractical.

Courts in other flood insurance cases have dealt with procedural issues such as running of the statute of limitations for filing insurance claims;²⁴⁴ payment of interest and attorney's fees;²⁴⁵ whether federal courts have exclusive jurisdiction over the flood insurance program (they do not, but federal law must be applied);²⁴⁶ and whether the federal government could assume issuance of policies from the National Flood Insurers Association (it could).²⁴⁷

Avoiding Legal Problems

During the 1980s state and local governments will be able to regulate floodplain areas with greater confidence because of the last decade's favorable court decisions on the taking issue, the sufficiency of floodplain enabling statutes, regulatory objectives, and maps. They can also adopt broader resource management programs with flood-hazard reduction components due to the widespread support for wetland, coastal zone, and other environmental regulations during the decade. Despite greater confidence, communities and states should carefully prepare and implement regulations to avoid legal problems. Where there are questions concerning

the validity of adoption procedures (e.g., for resolutions) regulations should be readopted.

States and local governments should design programs to avoid inverse condemnation ("taking") problems. One way of doing this is to focus regulatory goals and standards upon the "nuisance" impacts of floodplain activities such as cumulative increases in flooding, pollution, or other damages to adjacent, upstream, or downstream lands. Courts have been sympathetic to regulations designed to prevent any increased damage to other lands, including not only traditional floodways but also zero-rise floodway restrictions, dune protection regulations, flood storage and stormwater detention regulations, strict control of chemical and gasoline storage and other hazardous and nuisance uses in the floodplain. The difficulties posed by the taking issue can also be diminished by applying regulations consistently to similarly situated properties and by distinguishing between the application of regulations (controlling private use) and eminent domain powers (some measure of public use).

For less seriously flooded areas, regulations can permit low-density, flood-protected structural development or open spaces with economic return such as golf courses, agriculture, forestry, and recreation. The impacts of regulation can be reduced through cluster subdivision provisions, density bonus provisions, and real estate tax incentives. Special permit procedures can provide room for negotiation between landowners and the community or the state.

Comprehensive community planning and regulations and even-handed administration of regulations will also help to meet taking challenges because courts carefully examine the overall rationality and fairness of regulations in deciding whether a taking has occurred.

Governments should provide a sound factual base (maps and other data) for regulations and for the issuance and denial of permits since courts now examine the data base with increasing care. Floodplain maps should be upgraded as watershed conditions change, new flood data becomes available, or development pressures occur. Nevertheless, relatively small-scale and inaccurate maps may suffice where administrative procedures are available to upgrade data on a case-by-case basis as development permits are submitted.

It is also important that the raw data used to prepare maps be preserved for future support of regulations in court. Communities and states should retrieve such information from flood insurance study contractors before the data are lost. Contractors are required to keep it no longer than five years. It is also important that states and communities use experts in hydrology, water resources engineering, and other water-related subjects in fact finding to form the basis for issuance or denial of permits.

Governments should, to the extent possible, provide similar degrees of regulation for similarly situated flood-prone properties since courts are increasingly concerned with the fairness and equity of regulations. In general, regulatory agencies should define floodway lines to provide conveyance on both sides of a stream. However, mathematical precision is not necessary for setting boundaries. Uniform flood protection elevations should be applied to similarly flooded properties. Only when there are sound reasons should distinctions be made between similarly situated properties.

Regulations should be consistent with broader community and regional planning goals and guidelines. Courts more easily justify the rationale and equity of regulations that are based on soundly conceived short-term and long-term comprehensive data-gathering, planning, and regulatory

programs. Comprehensive data-gathering may include community-wide or regional resource inventories. Comprehensive planning may include that done for floodplain management, disaster mitigation, drainage, and land use management.

Governments should review floodplain permits and subdivision plans with care to avoid potential claims of liability which may arise if development increases flood heights. To avoid such liability, agencies may require that landowners whose activities increase flood heights on other lands purchase easements from other affected landowners. Governments should also define floodway boundaries to avoid substantial flood height increases. They should describe flood maps as approximate and warn that larger flood events may occur. Governments should also construct and operate drainage works, dikes, dams, and other flood control measures with increasing care in light of the emerging doctrines of municipal liability. In short, governments should avoid any action which may increase private flood damages.

CHAPTER VII

Footnotes

1. See discussion at p. 203.
2. 272 U.S. 365 (1926).
3. 277 U.S. 183 (1928).
4. See Water Resources Council *et al.* (1970), Appendix A, p. 467 and (1971).
5. *Id.* at 24. See also J. A. Kusler Associates (1975).
6. See Water Resources Council *et al.* (1970) at 59.
7. See J. A. Kusler Associates (1975) at 18.
8. See Water Resources Council *et al.* (1970) at 42.
9. *Id.* at 297.
10. *Id.* at 301, 314.
11. *Id.* at 392.
12. *Id.* at 326, 330, 338.
13. *Id.* at 326, 335.
14. *Id.* at 326.
15. *Id.* at 356, 364.
16. *Id.* at 340.
17. *Id.* at 340, 354.
18. *Id.* at 389.
19. *Id.* at 305, 392.
20. *Id.* at 302.
21. 283 N.W.2d 538 (Minn. 1979).
22. 276 N.W.2d 377 (Iowa 1979).
23. 395 N.E.2d 880 (Mass. App. Ct. 1979).

24. 387 N.E.2d 455 (Ind. App. 1979).
25. 88 Wash.2d 726, 565 P.2d 1162 (1977).
26. 173 N.J. Super. 311, 414 A.2d 280 (1980).
27. 362 Mass. 221, 284 N.E.2d 891 (1972), *cert. denied*, 409 U.S. 1108 (1973).
28. 57 A.D.2d 51, 394 N.Y.S.2d 913 (1977).
29. Mass. App. Ct. Adv. Sh. (1980) 637.
30. 24 C.A.3d 311, 101 Cal. Rptr. 93 (1972).
31. 116 N.J. Super. 148, 281 A.2d 377 (1971).
32. 90 Misc.2d 360, 394 N.Y.S.2d 517 (1977).
33. 126 N.J. Super. 200, 313 A.2d 624 (1973).
34. 247 N.W.2d 684 (S.D. 1976).
35. 430 F.2d 199 (5th Cir. 1970).
36. E.g., P.F.Z. Properties, Inc. v. Train, 393 F.Supp. 1370 (D.D.C. 1975).
37. Avoyelles Sportsmen's League v. Alexander, 473 F.Supp. 525 (W.D. La. 1979).
38. United States v. Byrd, 609 F.2d 1204 (7th Cir. 1979); Minnehaha Creek Watershed District v. Hoffman, 597 F.2d 617 (8th Cir. 1979).
39. 266 Md. 358, 293 A.2d 241 (1972), *cert. denied*, 409 U.S. 1040 (1972).
40. 116 R.I. 54, 352 A.2d 661 (1976).
41. 56 Wis.2d 7, 201 N.W.2d 761 (1972).
42. 115 N.H. 124, 336 A.2d 239 (1975).
43. 399 So.2d 1374 (Fla. 1981).
44. 57 A.D.2d 51, 394 N.Y.S.2d 913 (1977).
45. 243 Ga. 577, 255 S.E.2d 63 (1979), *cert. denied*, 440 U.S. 936 (1979).
46. E.g., Cinelli v. Whitfield Transportation, Inc., 83 N.M. 205, 490 P.2d 463 (1971); Hamlin v Matarazzo, 120 N.J. Super. 164, 293 A.2d 450 (1972).
47. 108 Ill.App.2d 230, 247 N.E.2d 47 (1969).
48. *Id.*, 247 N.E.2d at 51.
49. 120 N.J. Super. 164, 293 A.2d 450 (1972).

50. 495 S.W.2d 643 (Mo. 1973).
51. 40 A.D.2d 1005, 338 N.Y.S.2d 778 (1972).
52. See cases cited in notes 213-220 *infra*.
53. 362 Mass. 221, 284 N.E.2d 891 (1972), *cert. denied*, 409 U.S. 1108 (1973).
54. *Id.*, 284 N.E.2d at 876.
55. *Id.*, 284 N.E.2d at 876.
56. Moreland Development Co., Inc. v. City of Tulsa, 596 P.2d 1255 (Okla. 1979).
57. Famularo v. Board of County Commissioners of Adams County, 505 P.2d 958 (Colo. 1973).
58. Maple Leaf Investors Inc. v. State Department of Ecology, 88 Wash.2d 726, 565 P.2d 1162 (1977).
59. Lindquist v. Omaha Realty, Inc., 247 N.W.2d 684 (S.D. 1976).
60. 495 S.W.2d 643 (Mo. 1973).
61. 283 N.W.2d 538 (Minn. 1979).
62. 283 N.W.2d 918 (Minn. 1979).
63. 120 N.J. Super. 164, 293 A.2d 450 (1972).
64. Jefferson County v. Johnson, 333 So.2d 143 (Ala. 1976).
65. 596 P.2d 1255 (Okla. 1979).
66. 270 Md. 652, 313 A.2d 820 (1974).
67. 283 N.W.2d 918 (Minn. 1979).
68. 126 N.J. Super. 200, 313 A.2d 624 (1973).
69. 247 N.W.2d 684 (S.D. 1976).
70. *Id.*, 247 N.W.2d at 686.
71. 563 S.W.2d 239 (Tex. 1978).
72. Frisco Land and Mining Co. v. State, 74 Cal. App.3d 736, 141 Cal. Rptr. 820 (1977).
73. Adams v. North Carolina Dept. of Natural and Economic Resources, 295 N.C. 683, 249 S.E.2d 402 (1978).
74. New York City Housing Authority v. Commissioner of Environmental Conservation Department, 82 Misc.2d 89, 372 N.Y.S.2d 146 (1975).

75. Young Plumbing and Heating Co. v. Iowa Natural Resources Council, 276 N.W.2d 377 (Iowa 1979).
76. Maple Leaf Investors v. State Department of Ecology, 88 Wash.2d 726, 565 P.2d 1162 (1977).
77. Foreman v. State Department of Natural Resources, 387 N.E.2d 455 (Ind. App. 1979).
78. Usdin v. State Department of Environmental Protection, 173 N.J. Super. 311, 414 A.2d 280 (1980).
79. 270 Md. 652, 313 A.2d 820 (1974).
80. 92 Wash.2d 894, 602 P.2d 1172 (1979).
81. 240 Ga. 177, 240 S.E.2d 241 (1977).
82. Scott v. State ex. rel. State Highway Comm., 23 Ore. App. 99, 541 P.2d 516 (1975).
83. County of Pine v. State Department of Natural Resources, 280 N.W.2d 625 (Minn. 1979).
84. Frisco Land and Mining Co. v. State, 74 Cal. App.3d 736, 141 Cal. Rptr. 820 (1977); Brown v. Frement, 75 Cal. App.3d 141, 142 Cal. Rptr. 46 (1977).
85. Toms River Affiliates v. Department of Environmental Protection, 140 N.J. Super. 135, 355 A.2d 679 (1976).
86. Adams v. North Carolina Department of Natural and Economic Resources, 295 N.C. 683, 249 S.E.2d 402 (1978).
87. Horizon Adirondack Corp. v. State, 88 Misc.2d 619, 388 N.Y.S.2d 235 (1976).
88. Town of Monroe v. Carey, 96 Misc.2d 238, 412 N.Y.S.2d 939 (1977).
89. Turner v. County of Del Norte, 24 C.A.3d 311, 101 Cal. Rptr. 93 (1972).
90. Foreman v. State Department of Natural Resources, 387 N.E.2d 455 (Ind. App. 1979).
91. Young Plumbing and Heating Co. v. Iowa Natural Resources Council, 276 N.W.2d 377 (Iowa 1979).
92. Maple Leaf Investors v. State Department of Ecology, 88 Wash.2d 726, 565 P.2d 1162 (1977).
93. Krahl v. Nine Mile Creek Watershed District, 283 N.W.2d 538 (Minn. 1979).
94. Subaru of New England, Inc. v. Board of Appeals of Canton, 395 N.E.2d 880 (Mass. App. Ct., 1979).
95. American National Bank and Trust Company of Chicago v. Village of Winfield, 1 Ill. App.3d 376, 274 N.E.2d 144 (1971).

96. *Brown v. City of Joliet*, 108 Ill. App.2d 230, 247 N.E.2d 47 (1969).
97. *Metropolitan St. Louis Sewer District v. Zykan*, 495 S.W.2d 643 (Mo. 1973).
98. *Hamlin v. Matazzaro*, 120 N.J. Super. 164, 293 A.2d 450 (1972).
99. *Id.*
100. 362 Mass. 221, 284 N.E.2d 891 (1972), *cert. denied*, 409 U.S. 1108 (1973).
101. *Id.*, 284 N.E.2d at 896.
102. *Dur-Bar Realty Co. v. City of Utica*, 57 A.D.2d 51, 394 N.Y.S.2d 913, 918 (1977).
103. *Turnpike Realty Co. v. Town of Dedham*, 362 Mass. 221, 284 N.E.2d 891, 896 (1972), *cert. denied*, 409 U.S. 1108 (1973).
104. *Dur-Bar Realty Co. v. City of Utica*, 57 A.D.2d 51, 394 N.Y.S.2d 913, 918 (1977).
105. *Beckendorff v. Harris-Galveston Coastal Subsidence District*, 558 S.W.2d 75 (Tex. 1977).
106. *Id.*, 558 S.W.2d at 81.
107. *Sands Point Harbor, Inc. v. Sullivan*, 136 N.J. Super. 436, 346 A.2d 612 (1975); *Potomac Sand and Gravel Co. v. Governor of Maryland*, 266 Md. 358, 293 A.2d 241 (1972), *cert. denied*, 409 U.S. 1090; *J. M. Mills, Inc. v. Murphy*, 116 R.I. 54, 352 A.2d 661 (1976).
108. *In Re Sports Complex in Hackensack Meadowlands*, 62 N.J. 248, 300 A.2d 337 (1973).
109. *Maple Leaf Investors v. State Department of Ecology*, 88 Wash.2d 726, 565 P.2d 1162 (1977).
110. *Foreman v. State Department of Natural Resources*, 387 N.E.2d 455 (Ind. App. 1979).
111. *Young Plumbing and Heating Co. v. Iowa Natural Resources Council*, 276 N.W.2d 377 (Iowa 1979).
112. *A.H. Smith Sand and Gravel Co. v. Department of Natural Resources*, 270 Md. 652, 313 A.2d 820 (1974).
113. *State v. A. Capuano Bros., Inc.*, 384 A.2d 610 (R.I. 1978).
114. 24 C.A.3d 311, 101 Cal. Rptr. 93 (1972).
115. 362 Mass. 221, 284 N.E.2d 891 (1972), *cert. denied*, 409 U.S. 1108 (1973).
116. 55 A.D.2d 700, 388 N.Y.S.2d 952, 953 (1976).

117. *Id.*, 388 N.Y.S.2d at 954.
118. *Sturdy Homes, Inc. v. Tp. of Redford*, 30 Mich. App. 53, 186 N.W.2d 43 (1971).
119. *Iowa Natural Resources Council v. Van Zee*, 261 Iowa 1287, 158 N.W.2d 111 (1968).
120. 362 Mass. 221, 284 N.E.2d 891 (1972), *cert. denied*, 409 U.S. 1108 (1973).
121. *Id.*, 284 N.E.2d at 901.
122. *Just v. Marinette County*, 56 Wis.2d 7, 201 N.W.2d 761 (1972).
123. 473 F.Supp. 52 (N.D. Miss. 1979).
124. 427 F.Supp. 26 (D. Mass. 1976).
125. 276 N.W.2d 377 (Iowa 1979).
126. 283 N.W.2d 538 (Minn. 1979).
127. 395 N.E.2d 880 (Mass. App. Ct. 1979).
128. *Young Plumbing and Heating Co. v. Iowa Natural Resources Council*, 276 N.W.2d 377 (Iowa 1979).
129. 243 Ga. 577, 255 S.E.2d 63 (1979), *cert. denied*, 440 U.S. 936 (1979).
130. *Subaru of New England, Inc. v. Board of Appeals*, 395 N.E.2d 880 (Mass. App. Ct. 1979).
131. 563 S.W.2d 239 (Tex. 1978).
132. *Id.*, 558 S.W.2d 75, at 76 (Tex. Civ. App. 1977).
133. *MacGibbon v. Board of Appeals of Duxbury*, 340 N.E.2d 487 (Mass. 1976).
134. *Pope v. City of Atlanta*, 243 Ga. 577, 255 S.E.2d 63 (1979), *cert. denied*, 440 U.S. 936 (1979).
135. *Oakwood at Madison, Inc. v. Township of Madison*, 117 N.J. Super. 11, 283 A.2d 353 (1971).
136. 270 Md. 652, 313 A.2d 820 (1974).
137. *Roberts v. Secretary, Department of Housing and Urban Development*, 473 F.Supp. 52 (N.D. Miss. 1979).
138. *Young Plumbing and Heating Co. v. Iowa Natural Resources Council*, 276 N.W.2d 377 (Iowa 1979).
139. *Id.*, 276 N.W.2d at 389.
140. 242 Ga. 331, 249 S.E.2d 16 (1978).

141. See, e.g., *Brown v. City of Joliet*, 108 Ill. App.2d 230, 247 N.E.2d 47 (1969); *Turnpike Realty Co. v. Town of Dedham*, 362 Mass. 221, 284 N.E.2d 891 (1972), *cert. denied*, 409 U.S. 1108 (1973); *A. H. Smith Sand and Gravel Co. v. Dept. of Water Resources*, 270 Md. 652, 313 A.2d 820 (Md. App. 1974); *Foreman v. State Department of Natural Resources*, 387 N.E.2d 455 (Ind. App. 1979).
142. *Young Plumbing and Heating Co. v. Iowa Natural Resources Council*, 276 N.W.2d 377 (Iowa 1979).
143. *Id.*, 276 N.W.2d at 383.
144. *Id.*, 276 N.W.2d at 388.
145. *Id.*, 276 N.W.2d at 384.
146. See cases cited in notes 151-166 *infra*.
147. E.g., *Turner v. County of Del Norte*, 24 C.A.3d 311, 101 Cal. Rptr. 93 (1972); *Zisk v. City of Roseville*, 127 Cal. Rptr. 896, 56 Cal. App.3d 41 (1976).
148. E.g., *Turnpike Realty Co., Inc. v. Town of Dedham*, 362 Mass. 221, 284 N.E.2d 891 (1972), *cert. denied*, 409 U.S. 1108 (1973); *Subaru of New England, Inc. v. Board of Appeals of Canton*, 395 N.E.2d 880 (Mass. App. Ct. 1979).
149. E.g., *MacGibbon v. Board of Appeals*, 340 N.E.2d 487 (Mass. 1976).
150. *A. H. Smith Sand and Gravel Co. v. Dept. of Water Resources*, 270 Md. 652, 313 A.2d 820, 828 (1974).
151. See, e.g., cases cited in notes 21-28 *supra*.
152. *Pope v. City of Atlanta*, 242 Ga. 331, 249 S.E.2d 16 (1978).
153. *Id.*, 249 S.E.2d at 18.
154. *Just v. Marinette County*, 56 Wis.2d 7, 201 N.W.2d 761 (1972).
155. *Maple Leaf Investors v. State Department of Ecology*, 88 Wash.2d 726, 565 P.2d 1162 (1977).
156. *Turnpike Realty Co. v. Town of Dedham*, 362 Mass. 221, 284 N.E.2d 891 (1972), *cert. denied*, 409 U.S. 1108 (1973).
157. 57 A.D.2d 51, 394 N.Y.S.2d 913 (1977).
158. *Wolfram v. Abbey*, 55 A.D.2d 700, 388 N.Y.S.2d 952 (1976).
159. *Id.*, 388 N.Y.S.2d at 953.
160. 340 N.E.2d 487, (Mass. 1976).
161. *Pope v. City of Atlanta*, 243 Ga. 577, 255 S.E.2d 63 (1979), *cert. denied*, 440 U.S. 936, (1979). The court also held that cumulative impact was one of several considerations in evaluating a permit.

162. 406 A.2d 577 (Pa. Commw. 1979).
163. *Id.*, 406 A.2d at 578.
164. *Id.*, 406 A.2d at 578.
165. 41 N.Y.2d 438, 361 N.E.2d 1028, 393 N.Y.S.2d 379 (1977).
166. *Id.*, 361 N.E.2d at 1033.
167. *Scheff v. Tp. of Maple Shade*, 149 N.J. Super. 448, 374 A.2d 43, (A.D. 1977).
168. 553 S.W.2d 721 (Mo. 1977).
169. See discussion accompanying notes 221, 222.
170. 98 S.Ct. 2646 (1978).
171. *Id.*, 98 S.Ct. at 2659.
172. 100 S.Ct. 2138 (1980), *aff'g* 24 Cal.3d 266, 598 P.2d 25 (1979).
173. *Id.*, see 100 S.Ct. at 2142 where this language is cited.
174. *Id.*
175. 101 S.Ct. 1287 (1981).
176. 101 S.Ct. at 1294.
177. 101 S.Ct. at 1307.
178. See discussion in Kusler (1972).
179. *Id.*, see also note 221 *infra*.
180. E.g., *Krahl v. Nine Mile Creek Watershed District*, 283 N.W.2d 538 (Minn. 1979); *Moskow v. Commissioner of the Dept. of Environmental Management*, 427 N.E.2d 750 (Mass. 1981).
181. E.g., *Maple Leaf Investors v. State Department of Ecology*, 88 Wash.2d 726, 565 P.2d 1162 (1977); *Foreman v. State Department of Natural Resources*, 387 N.E.2d 455 (Ind. App. 1979); *Kraiser v. Zoning Hearing Bd. of Horsham Tp.*, 406 A.2d 577 (Pa. Commw. 1979); *Krahl v. Nine Mile Creek Watershed District*, 283 N.W.2d 538 (Minn. 1979); *Turner v. County of Del Norte*, 24 C.A.3d 311, 101 Cal. Rptr. 93 (1972).
182. E.g., *Turner v. County of Del Norte*, 24 C.A.3d 311, 101 Cal. Rptr. 93 (1972); *Young Plumbing and Heating Co. v. Iowa Natural Resources Council*, 276 N.W.2d 377 (Iowa 1979); *Foreman v. State Department of Natural Resources*, 387 N.E.2d 455 (Ind. App. 1979).
183. *Lorio v. City of Sea Isle*, 88 N.J. Super. 506, 212 A.2d 802 (1965). Construction of a sand dune on private property is a taking.

184. E.g., *Krahl v. Nine Mile Creek Watershed District*, 283 N.W.2d 538 (Minn. 1979); *Maple Leaf Investors v. State Department of Ecology*, 88 Wash.2d 726, 565 P.2d 1162 (1977).
185. E.g., *Maple Leaf Investors v. State Department of Ecology*, 88 Wash.2d 726, 565 P.2d 1162 (1977); *Pope v. City of Atlanta*, 240 Ga. 177, 240 S.E.2d 241 (1977).
186. *Maple Leaf Investors v. State Department of Ecology*, 88 Wash.2d 726, 565 P.2d 1162 (1977).
187. *Id.*; see also *Foreman v. State Department of Natural Resources*, 387 N.E.2d 455 (Ind. App. 1979).
188. E.g., *Krahl v. Nine Mile Creek Watershed District*, 283 N.W.2d 538, (Minn. 1979); *Turner v. County of Del Norte*, 24 C.A.3d 311, 101 Cal. Rptr. 93 (1972); *Subaru of New England, Inc. v. Board of Appeals of Canton*, 395 N.E.2d 880 (Mass. App. Ct. 1979).
189. See notes 132, 134, *supra*; *Krahl v. Nine Mile Creek Watershed District*, 283 N.W.2d 538 (Minn. 1979).
190. *Moskow v. Commissioner of the Department of Environmental Management*, 427 N.E.2d 750 (Mass. 1981).
191. *Id.*, 427 N.E.2d at 754.
192. E.g., *Maple Leaf Investors v. State Department of Ecology*, 88 Wash.2d 726, 565 P.2d 1162 (1977); *Young Plumbing and Heating Co. v. Iowa Natural Resources Council*, 276 N.W.2d 377 (Iowa 1979).
193. E.g., *Spiegle v. Borough of Beach Haven*, 116 N.J. Super. 148, 281 A.2d 377 (1971); *County of Ramsey v. Stevens*, 283 N.W.2d 918 (Minn. 1979).
194. E.g., *Turnpike Realty Co. v. Town of Dedham*, 362 Mass. 221, 284 N.E.2d 891 (1972), *cert denied*, 409 U.S. 1108 (1973); *Turner v. County of Del Norte*, 24 C.A.3d 311, 101 Cal. Rptr. 93 (1972). See also cases cited in notes 21-31 *supra*.
195. See cases cited in note 180 *supra*.
196. E.g., *Spiegle v. Borough of Beach Haven*, 116 N.J. Super. 148, 281 A.2d 377 (1971); *Turner v. County of Del Norte*, 24 C.A.3d 311, 101 Cal. Rptr. 93 (1972); *Foreman v. State Department of Natural Resources* 387 N.E.2d 455 (Ind. App. 1979).
197. *Just v. Marinette County*, 56 Wis.2d 7, 201 N.W.2d 761 (1972).
198. See cases cited in notes 156, 157, *supra*.
199. See *Water Resources Council et al.* (1972).
200. 657 F.2d 1184 (Ct. Cl. 1981).
201. 56 Wis.2d 7, 201 N.W.2d 761 (1972).

202. *Id.*, 201 N.W.2d at 768.
203. 266 Md. 358, 293 A.2d 241 (1972), *cert. denied*, 409 U.S. 1040 (1972).
204. 136 N.J. Super. 436, 346 A.2d 612 (Super. Ct. App. Div. 1975).
205. *County of Pine v. State, Department of Natural Resources*, 280 N.W.2d 625 (Minn. 1979).
206. *Scott v. State ex. rel. State Highway Comm.*, 23 Ore. App. 99, 541 P.2d 516 (1975).
207. *State v. Superior Court of Orange County*, 12 Cal.3d 237, 524 P.2d 1281, 115 Cal. Rptr. 497 (1974).
208. *Toms River Affiliates v. Dept. of Environmental Protection*, 140 N.J. Super., 355 A.2d 679 (1976).
209. *Adams v. North Carolina Dept. of Natural and Economic Resources*, 295 N.C. 683, 249 S.E.2d 402 (1978).
210. E.g., *Gisler v. County of Madera*, 38 Cal. App.3d 303, 112 Cal. Rptr. 919 (1974).
211. *Just v. Marinette County*, 56 Wis.2d 7, 201 N.W.2d 761 (1972).
212. E.g., *State Dept. of Ecology v. Pacesetter Const. Co.*, 89 Wash.2d 203, 571 P.2d 196 (1977).
213. 283 N.W.2d 918 (Minn. 1979).
214. E.g., *Long v. City of Highland Park*, 329 Mich. 146, 45 N.W.2d 10 (1950); *Kissinger v. City of Los Angeles*, 161 Cal. App.2d 454, 327 P.2d 10 (1958).
215. 24 Cal. App.3d 311, 101 Cal. Rptr. 93 (1972)
216. 387 N.E.2d 455 (Ind. App. 1979).
217. 127 Cal. Rptr. 896, 56 Cal. App.3d 41 (1976).
218. *Gaebel v. Thornbury Township, Delaware County*, 8 Pa. Commw. Ct. 379, 303 A.2d 57 (1973).
219. *Krahl v. Nine Mile Creek Watershed District*, 283 N.W.2d 538 (Minn. 1979).
220. *Kessler v. Town of Shelter Island Planning Board*, 40 A.D.2d 1005, 338 N.Y.S.2d 778 (1972).
221. 30 Mich. App. 53, 186 N.W.2d 43 (1971).
222. 1 Ill. App.3d 376, 274 N.E.2d 144 (1971).
223. *Lemp v. Town Board of Town of Islip*, 90 Misc.2d 360, 394 N.Y.S.2d 517 (1977).

224. United States v. Sponenbarger, 308 U.S. 256, (1939). B Amusement Company v. United States, 180 F.Supp. 386, (Ct.Cl. 1960).
225. See generally Oahe Conservancy Sub-District v. Alexander, 493 F.Supp. 1294 (D. South Dakota 1980).
226. Barnes v. United States, 538 F.2d 865 (Ct.Cl. 1976).
227. 48 Ohio St.2d 334, 358 N.E.2d 598 (1976). See also: Myotte v. Village of Mayfield, 54 Ohio App.2d 97, 375 N.E.2d 816 (1977). Court held that a municipality which issued a building permit for an industrial complex and partially improved a drainage system, but not an appellant's land, was liable for increased run-off.
228. E.g., Myotte v. Village of Mayfield, 54 Ohio App.2d 97, 375 N.E.2d 816 (1977); Sheffet v. County of Los Angeles, 3 Cal. App.3d 720, 84 Cal. Rptr. 11 (1970).
229. 24 Cal. App.3d 311, 101 Cal. Rptr. 93 (1972).
230. 283 N.W.2d 918 (Minn. 1979).
231. 8 Pa. Commw. Ct. 379, 303 A.2d 57 (1973).
232. 453 F.Supp. 1025 (D.D.C. 1978), aff'd 598 F.2d 311 (D.C. Cir. 1979), cert. denied, 100 S.Ct. 267 (1979).
233. 520 F.2d 11 (1975) on remand, 420 F.Supp. 221 (M.D. Pa. 1976).
234. 473 F.Supp. 52 (N.D. Miss. 1979).
235. 427 F.Supp. 26 (D. Mass. 1976).
236. Jeremy & Sons, Inc. v. Commercial Union Assurance Companies, 398 F.Supp. 374 (N.D. Ohio 1975).
237. Segal v. Great American Insurance Co., 390 F.Supp. 1074 (E.D.N.Y. 1974).
238. Mason v. National Flood Insurers Association, 361 F.Supp. 939 (D. Hawaii 1973).
239. Jackson v. National Flood Insurers Association, 398 F.Supp. 1383 (S.D. Texas 1974).
240. West v. Harris, 573 F.2d 873 (5th Cir. 1978), cert. denied, 440 U.S. 946 (1979); Zabel v. Tabb, 430 F.2d 199 (5th Cir. 1970), cert. denied, 401 U.S. 910 (1971).
241. Presley v. National Flood Insurers Association, 399 F.Supp. 1242 (E.D. Mo. 1975); Summers v. Harris, 573 F.2d 869 (5th Cir. 1978).
242. Horeftis v. National Flood Insurers Association, 437 F.Supp. 794 (E.D. Mich. 1977).
243. 479 F.Supp. 3 (M.D. Penn. 1978).

244. *Nunnery v. Insurance Companies, Members of National Flood Insurers Association*, 414 F.Supp. 973 (N.D. Miss. 1976); *Horeftis v. National Flood Insurers Association*, 437 F.Supp. 794 (E.D. Mich. 1977).
245. *Davis v. Aetna Casualty and Surety Co.*, 329 So.2d 868, (Ct. App. La. 1976); *Bains v. Hartford Fire Insurance Co.*, 440 F.Supp. 15 (N.D. Ga. 1977).
246. *Davis v. Aetna Casualty and Surety Company*, 329 So.2d 868, (Ct. App. La. 1976); *Bains v. Hartford Fire Insurance Co.*, 440 F.Supp. 15 (N.D. Ga. 1977); *Mason v. National Flood Insurers Association*, 431 F.Supp. 1021 (N.D. Okla. 1977); *Burrell v. Turner Corp.*, 431 F.Supp. 1018 (N.D. Okla. 1977); *Drewett v. Aetna Casualty and Surety Co.*, 539 F.2d 496 (5th Cir. 1976).
247. *National Flood Insurers Association v. Harris*, 444 F.Supp. 969 (D.D.C. 1977).

CHAPTER VIII

STRATEGIES FOR THE 1980s

Chapters I through VII detailed progress and problems with floodplain management in the 1970s. This chapter deals with strategies for the 1980s to improve the effectiveness of regulations in combination with other management techniques not only to reduce flood losses but also to achieve broad economic and social goals. The first section describes overall strategies, including measures to reduce costs. The next section covers recommendations for specific local, state, and federal actions. The final section discusses subjects that need further research.

Overall Strategies

In the 1970s, federal, state, and local governments made progress in developing an overall policy to reduce future flood losses by requiring that new development and redevelopment be protected from flooding and applying hazard reduction measures to existing uses. Judicial support for these floodplain regulations was overwhelming. Even so, serious gaps and deficiencies remain in mapping, technical assistance, and regulations. Program coordination is incomplete and much work to implement policies remains.

If the thousands of state and local programs already under way are to be implemented, federal philosophy must shift during the 1980s. To date, FEMA has primarily encouraged local adoption of regulations by providing insurance incentives and generalized maps, standards, guidelines, and information. Now, technical assistance, more specific flood studies, wider application of federal expertise, and more flexibility in standards and criteria are needed to support state and local implementation of site-specific aspects of floodplain management. To do this, federal technical assistance, training, education, mapping, and standard-setting

should be geared to the differing needs of each area but within a continued framework of overall standards (e.g., the 100-year flood standard). For example, metropolitan flood hazard regulations should include provisions for stormwater management. As far as possible, federal support should encourage rather than discourage a tailoring of programs.

All levels of government should focus on ten types of action.

- (1) Improving flood studies not only to reflect actual hazards (wave heights, erosion, future watershed conditions) but also to delineate topographic contours, existing structures, roads, and other features;
- (2) Upgrading interim regulations and resolutions to avoid legal problems, reduce delays in permit processing, and provide certainty to landowners;
- (3) Improving the administration, monitoring, and enforcement of floodplain regulations by increasing state and local expertise in planning, assessment of hazards and natural values, regulation, acquisition, relocation, flood warning systems, flood control works and flood insurance;
- (4) Developing predisaster and postdisaster plans to guide public investment and reduce losses to existing private and public uses;
- (5) Combining regulations and nonregulatory measures to reduce the damage potential of existing uses and to serve multipurpose community goals;
- (6) Guiding public works projects and public investment in the floodplain to avoid floodways and high hazard areas and to incorporate floodproofing measures;
- (7) Educating public officials, floodplain occupants, bankers, local governmental officials and architects in the details of flood loss reduction measures;
- (8) Coordinating or integrating floodplain plans with broader community and regional planning to serve multipurpose goals;
- (9) Revising federal, state, and local subsidies for flood insurance, disaster assistance, and floodplain regulations in order to provide incentives to floodplain occupants and local governments to develop their own self-help techniques for reducing flood losses;
- (10) Testing, documenting, and publicizing the long-term effectiveness of alternative flood loss reduction methods.

Reduced federal, state, and local spending in the 1980s may severely strain personnel, resources, and the implementation of flood damage reduction measures. High capital outlays and maintenance costs will make structural measures particularly difficult to implement. Funds to implement nonstructural measures may also be reduced. However, if governmental response to flood disasters over the last 50 years is any guide, arguments that regulations should be reduced to save government funds and that floodplain occupants be permitted to bear flood losses as they see fit are unrealistic. Once a flood occurs, public opinion or concern for flood victims forces Congress and state legislatures to appropriate monies for disaster relief, rebuilding, and flood control measures. An "ounce of prevention" is needed.

The combination of nonstructural floodplain measures along with regulations supports the cost-effective objective that those who occupy the floodplain should be responsible for the results of their own actions.¹ This type of management can also support cost-effective, multipurpose community goals such as less expensive municipal services (roads, sewers), optimum use of natural resources (water supply, agricultural land, timber, fish, and wildlife), renewal of blighted areas, and protection of the tax base, which is usually lowered when flood damage occurs.

Even though proponents of free market decision making usually fail to address the principal problem of uncontrolled floodplain activities--their long-term external costs--regulations will continue to be challenged during the next decade on philosophical grounds and as restraints to private and local government decision making. The alternative--piecemeal dismantling of regulations--would permit continued landowner irresponsibility. The floodplain landowner has little incentive to consider the external costs of increased flood heights and velocities, or the damages to other property caused by fill, dams, or buildings. Instead

of relaxing regulations, planners and managers should focus on improving the quality of regulations, thereby reducing landowners' objections. Acquisition can also be used to minimize problems and reduce ultimate costs.

Floodplain regulations can be simplified and streamlined. More specific floodplain standards offer landowners more certainty about their use of the land. If states and localities adopt joint procedures for regulating floodplains and wetlands they can reduce the total time required for project review. Regulatory standards can be better tailored to special problems and needs and tax incentives can be coordinated to support regulations. Regulations can be incorporated into broader packages of floodplain management techniques to improve their quality and effectiveness.

Several strategies are available to improve floodplain management in spite of tight budgets.

- Program priorities should be carefully established. All levels of government should focus their mapping, planning, regulations, education, and technical assistance on areas subject to the most severe flood hazards and development pressures. Good examples are barrier islands and inland areas subject to flash floods.
- Funds should be reallocated to floodplain management techniques that have the greatest long-term cost effectiveness. For example, the federal grants to improve state floodplain management capability (now at a total level of \$3 million) may be a better federal investment than the construction of a single small dam. In the long run, public acquisition of damage-prone properties may cost federal taxpayers less than repeated payment of flood insurance claims.
- Multipurpose programs should be encouraged. For grants in aid, technical assistance, and mapping, preference should be given to states and localities with multiobjective floodplain planning and management programs. This will not only reduce flood losses but also support urban renewal, open space protection, and other social and environmental programs.
- Those who benefit from flood loss reduction measures should be made to bear a larger portion of the costs of such measures. Consistent federal policies are needed to require state, local, and private cost-sharing in flood control works, disaster assistance, acquisition, and other hazard reduction measures.

This will reduce federal outlays and encourage states and localities to assume their share of the responsibilities.

- State and local floodplain management roles should be enhanced. State and local training and education, monitoring, permit processing, and acquisition are often more cost-effective than comparable federal programs because their staffs are closer to the problems, their pay scales are generally lower, duplication of work is reduced, and the personnel can be shared more easily with ongoing programs.
- Executive orders and state and local guidelines for public uses should be enforced. The Floodplain Management Executive Order and similar state and local guidelines for public uses that require either avoidance of flood hazards or flood protection should be carefully enforced. Their implementation can not only reduce future losses to the uses but also discourage private development which is often attracted by public services in the floodplain.
- The Disaster Assistance Act of 1973 requirements that hazard mitigation measures be adopted as a condition to federal disaster assistance should be consistently and vigorously enforced to reduce continued losses in frequently flooded areas.
- Flood loss reduction measures with long-term cost effectiveness and built-in safety factors should be emphasized. It is often more cost-effective to acquire and relocate structures than to support repeated flood losses at public and private expense. Elevation provides a greater built-in safety factor than levees and channeling. Acquisition or regulation to maintain open floodplains or floodways to protect their flood storage and natural conveyance capacities will often cost less than construction of flood control works.
- More flexible federal mapping criteria should be adopted. Managers should compare the costs of developing accurate and detailed area-wide flood studies with those for conducting case-by-case analyses of individual permits.
- Flood insurance rates should reflect the total risk. This will increase revenues for the flood insurance program and remove the present incentive to develop in areas where it is economically unjustified to do so.
- Government incentives for private self-help should be increased. Flood insurance rates and income tax or other economic incentives should be revised to motivate private floodplain occupants to assume responsibility for reducing flood damage. Instruction should be provided to private landowners (residential, commercial, industrial) on how to establish flood warning systems, install floodproofing, and develop other loss-reducing measures. These measures can simultaneously support other goals such as energy efficiency. The public can be educated through brochures, workshops, or one-on-one consultations. Bankers, lawyers, architects, engineers, and others

who advise landowners or finance, design, or build structures in the floodplain should be educated on the nature of flood hazards and on the economic value of flood protection measures.

- To facilitate evaluation of flood loss reduction measures on a national basis, a quantified national goal of holding flood losses to no more than a fixed average figure per year or reducing losses (e.g., \$2.5 billion per year through 1990) might be adopted. The effectiveness of regulations and other public and private flood loss reduction programs could be measured against such a quantified standard. This would facilitate the setting and balancing of federal budgets.

Local, State, and Federal Roles

The federal, state, and local partnership for floodplain management set forth in A Unified National Program for Flood Plain Management was tested during the 1970s. The partnership reflects a workable hierarchy of efforts which should continue to be implemented in the 1980s. State and local regulation, acquisition, and other floodplain management measures should be the basic elements of a unified program. The federal government should set standards, establish incentives, and provide technical assistance to support state and local programs. Implementation of the working partnership will require that the federal government understand and be responsive to state and local needs; and that states and local governments, in turn, accept greater responsibility for floodplain management.

Local Programs

With state and federal help, the 17,000 local floodplain management programs that have already been initiated should be fully implemented. Implementation of local floodplain management, tailored to local problems and needs, is the key to cost-effective flood loss reduction. Local governments are in the best position to implement comprehensive floodplain management: they are closest to the problems, and have broad powers to regulate, acquire, zone, and tax property. In addition, they are rou-

tinely involved in comprehensive land use planning and day-to-day management. Moreover, they have the greatest incentive for packaging and coordinating programs since flooding most seriously affects their residents, jobs, and tax base.

For some communities, implementation will be relatively straightforward--adoption of zoning and subdivision regulations consistent with maps provided by FEMA, NOAA, TVA, SCS, the Corps, USGS, or the states. Others need maps and regulations tailored to local conditions and combinations of regulatory and nonregulatory approaches.

Specific recommendations for local governments are:

Local governments should carefully formulate management goals for public and private use of floodplains. These goals can then be translated into site-specific plans and implementation measures. In setting goals, community leaders should view floodplain management as an opportunity to achieve a community's economic, social, and environmental objectives, not simply as a means to reduce flood losses. Through relocation or floodproofing, the community can correct past land use mistakes. In formulating goals, the community should also evaluate the severity of flood problems; the natural floodplain capacities and the cost of replacing those capacities at upland sites if the land is developed; the availability of other sites in the community for development; the costs of public services; and state and local standards.

Local governments should form special work groups or obtain the help of statutory bodies such as conservation commissions to develop policies and advise them on floodplain problems. These groups can ensure broad-based community involvement in policy and plan formulation. Local planners and engineers and state floodplain management personnel can often provide expert assistance. Private con-

sultants and federal agencies such as the Corps, FEMA, TVA, and SCS can also provide guidance.

Some communities need to prepare more detailed studies of flooding or natural resources to assist policy formulation and planning and to provide the basis for later implementation. Communities generally need more detailed studies for areas that are under intense development pressures or that are candidates for redevelopment. Such areas usually require maps at scales of 1"=100' to 1"=400'. For urbanizing and urban areas, maps should show topographic contours and existing uses, as well as flood, floodway, and wetland boundaries.

Communities should integrate or carefully coordinate floodplain management with management of wetlands, wild and scenic rivers, prime agricultural lands, and mineral resources. This may be accomplished in part through maps showing floodplains and broader resource areas (e.g., Sanibel, Florida). Resource protection standards may be incorporated into floodplain regulations and, vice versa, floodplain standards may be incorporated into resource protection regulations. Acquisition and tax incentives can be combined with regulations to achieve multipurpose goals.

Communities should adopt floodplain regulatory standards that are appropriate to their multipurpose needs rather than rely on minimum NFIP and state standards. For example, if a community is guiding all new development to upland sites, it can present losses not only to the users themselves but also to public facilities that serve them. This strategy will avoid the potential residual problems of

floodplain development that will lead to future flood losses (e.g., deterioration of pilings or of structural floodproofing). Development may be guided to upland sites through zoning and other regulations, but also by educating the public, marking hazard areas, and providing density bonuses and real estate tax incentives. Guiding all new development to upland sites is often feasible in areas where there is little or no development in the floodplain or where the floodplain is narrow.

Communities should emphasize flood adjustment measures with built-in safety factors such as elevation on fill instead of on wood pilings.

Regulations should be specifically tailored to the hazard at the given location, including combined storm surge, wave, and erosion problems in coastal areas; high velocity flows in mountain areas; and fluctuating water levels near lakes. To avoid increased flood damages to existing floodplain development and to lands presently beyond floodplain boundaries, communities should implement strict floodway and flood storage regulations.

Communities in the emergency program of the NFIP should upgrade the "resolutions" they adopted to join the regular program. More permanent regulations requiring case-by-case analysis of flood hazards may be appropriate if there are no maps to show 100-year flood elevations, floodways, or coastal velocity zones. Communities in the regular program should upgrade their regulations as needed. This is particularly important for coastal and barrier island communities that have not evaluated wave heights and erosion problems and for inland communities that have high velocity flows and long-term fluctuations in water levels.

Local governments within metropolitan areas should cooperate to integrate their stormwater management and floodplain regulations to provide regional hazard reduction and reduce the effects of urbanization on flood flows.

Communities should improve their own monitoring of development and enforcement of regulations by performing field checks before and after construction. They should inventory nonconforming uses. Citizens and members of interest groups should be encouraged to report violations.

Local governments should educate and train floodplain landowners and other decision makers in flood loss avoidance and reduction. Education techniques can include distribution of flood maps and brochures; marking flood hazard areas; workshops; television, radio, and newspaper ads; and one-on-one discussions. Communities can distribute floodplain management information to individual property owners with tax information (as in Avalon, New Jersey).

Local governments should carefully tailor nonconforming use regulations to local flood conditions and the impact of existing uses upon such conditions. Either before or after a flood, communities should survey existing damage-prone uses to determine the types and degree of nonconformity and the floodproofing and relocation potential. This information can form the basis for more specific regulation and short- and long-term plans for urban renewal, floodplain management, and postdisaster response.

Based on such surveys, communities can tighten "substantial improvement" criteria in their building codes, zoning, or other regulations to control repair or rebuilding in excess of 30% or 40% of pre-flood values for fill and structures in floodways. Amortization provisions with short- or long-term repair or termination dates can also be adopted.

Public education programs and workshops could also encourage voluntary floodproofing and relocation. Such programs may be particularly effective for industrial and commercial uses.

With this information, communities can also prepare flood warning systems and flood evacuation and emergency preparedness plans. Corrective measures such as ring dikes, levees, or channel modifications may also be applied.

After a flood, local governments can often adopt temporary moratoria on rebuilding until flood mitigation plans and policies are completed (as in Rapid City, South Dakota). Flood insurance payments, disaster grants and loans, and other financial measures can be combined with regulations to encourage or require relocation or floodproofing (as in Lake Elsinore, California). Relocation can often serve multi-purpose objectives, including stormwater management, urban renewal, and energy conservation (as in Soldiers Grove, Wisconsin).²

State Roles

State legislatures and agencies should also strengthen the state role in floodplain management, especially along the coasts and in inland rural areas that lack maps and have little or no local floodplain manage-

ment expertise. Even though some states need improved programs, it is unclear whether they wish to or will assume added responsibility for floodplain management without federal support, including technical assistance, mapping, and grants in aid.

Specific strategies are:

Legislatures should adopt new legislation or amend existing regulatory powers to clarify those powers and authorize nonregulatory measures such as acquisition (e.g., as in Arizona) to supplement regulations. Although direct state regulation may be generally appropriate for floodway and coastal high hazard areas, state standard-setting for local regulation is often most appropriate for flood fringe areas. State standard-setting for local regulations builds on both state and local capabilities. The state can assist localities by coordinating state, local, and federal programs; providing maps; assisting with evaluation of individual permits; assisting with the design of flood control projects; advising on local monitoring and enforcement of regulations; and training and educating local officials, landowners, and lenders.

States should develop their own standards and guidelines rather than rely on minimum NFIP standards where needed to meet multipurpose land and water management goals. These include standards for mapping; nonconforming uses; floodproofing; and special flood problems such as high velocity flow areas, floodways, lakeshores, alluvial fans, and erosion areas.

States should either develop more detailed maps or initiate cooperative state, local, and federal mapping on a watershed basis if federal maps are inadequate. Maps should show existing uses, topo-

graphic contours, wetlands, and other pertinent resources. To facilitate or carry out mapping, states may act as study contractors to FEMA (e.g., as in Maryland and New Jersey), undertake their own independent mapping (e.g., as in California), or financially and technically assist local governments in mapping (e.g., as in Wisconsin).

States should strengthen their clearinghouse and coordination function for local, state, and federal activities that affect floodplains. These activities include public works projects, permits, subdivision proposals, local ordinances, grants in aid, and disaster assistance payments. Such functions can be performed pursuant to state A-95 review procedures, environmental impact review procedures, floodplain management acts and executive orders, permitting and subdivision review powers, disaster preparedness and response, and civil defense powers. States should also help federal agencies and localities "package" grants in aid, technical assistance, and other measures (e.g., flood control works) to facilitate multipurpose floodplain management.

States should apply or encourage communities to apply innovative combinations of nonregulatory as well as regulatory techniques. They can do this through guidebooks, workshops, grants in aid, and education.

States should carry out additional public education and technical assistance. Such activities may include preparing and distributing model ordinances and brochures on flood preparedness and response and floodplain management; conducting workshops and training

sessions for local officials, lawyers, architects, planners, lenders, engineers, and landowners; marking flood hazard areas; distributing maps; and conducting one-on-one meetings with developers, local government officials, and the public.³

Federal Roles

Although state and local initiative and responsibility are essential to sound floodplain management in the 1980s, many local governments lack the expertise, funds, and size (i.e., they often encompass only part of the watershed) to carry out programs without help. Insufficient personnel and funds also constrain state programs. States and communities will need continued federal technical, mapping, and other assistance. However, federal monies should be spent only where states and communities are willing to make positive efforts to reduce flood problems. The test for federal programs should be, "How can the federal government reduce its own losses and best help floodplain occupants, local governments, and states help themselves?" To this end, FEMA, OMB, and other federal agencies should vigorously enforce the Floodplain Management Executive Order to reduce public investment that is proposed for floodplain areas and to set hazard mitigation examples for states and local governments. As discussed above, the federal government should respond to state and local needs with greater specificity in mapping, standard-setting, technical assistance, and training and education. Other strategies are:

Congress, OMB, FEMA, and other agencies should help states to enhance their floodplain management capability. To achieve this, Congress and OMB should continue FEMA grants in aid (State Assistance Program) to states that are willing to build their floodplain management programs and assume some of the responsibilities currently carried out by federal agencies, e.g., monitoring

community compliance with the NFIP. Congress and federal agencies should also involve states more fully in establishing federal policies for water resources projects, flood insurance rates, disaster assistance, and other flood-related measures.

Federal agencies should encourage states and communities to adopt innovative, multipurpose floodplain management programs for pre- and postflood situations⁴ by

- Stressing the minimal nature of federal standards and maps;
- Providing increasingly specific technical assistance and standards, including upgraded flood studies;
- Developing "how-to" manuals and guidebooks with examples of innovation and distributing them to local governments;
- Funding floodplain acquisition, flood warning systems, and other measures to supplement regulations;
- Streamlining ways to "package" federal grants for multipurpose projects such as community development block grants and open space funds, with special bonuses to communities proposing multipurpose projects;
- Coordinating federal programs and policies with state and local programs for flood insurance, land acquisition, disaster assistance, wetland protection, and public land management. Coordination can be improved through post-disaster assessment teams (now required), interagency review of projects pursuant to Executive Order 11988 procedures, joint processing of permits, joint research projects, and dissemination of research and program status information.

Congress, OMB, and FEMA should revise subsidy and cost-sharing policies to provide incentives for state, local, and private self-help by

- Revising subsidized NFIP rates to reflect the actual costs of floodplain occupancy;
- Clarifying and enforcing conditions for disaster assistance in order to require improved predisaster planning and adoption of mitigation measures after a disaster;
- Modifying federal criteria for water resources projects to balance structural with nonstructural floodplain

management. This should be done by disallowing land enhancement benefits for new development behind flood control works where alternative sites are available;

- Requiring consistent state and local cost-sharing in flood control measures, disaster assistance, and flood insurance. This would remove the present bias toward flood control works and encourage balanced state and local floodplain management;
- Monitoring state and local regulations and other hazard reduction measures to ensure that the federal investment in flood insurance, disaster assistance, flood control works, and other measures achieves desired results.

FEMA, the Corps, USGS, SCS, and NOAA should upgrade federal or joint federal, state, and local flood studies and maps to facilitate land use management.⁵ The agencies should develop the studies in cooperation with the states and localities for selected priority areas. Although arguments for uniformity in federal studies were once used to justify the present system of nationwide mapping, those arguments lose force as specific and unique implementation needs arise. Costs might be shared for studies reflecting state and local needs such as alternative floodway definitions.

Upgrading of studies should involve:

- Improved criteria for defining the 100-year flood elevation, floodway, and coastal high hazard areas. The criteria should include wave heights, wave runup and erosion for coastal areas, and flood velocities for inland high-velocity flow areas. New regional hydrologic information that includes changing flood conditions is needed for large urban and metropolitan areas. Maps should also show data on erosion areas, wetlands and existing uses. More detailed flood studies that include smaller contour intervals and larger map scales are needed. However, a partial trade-off between flood study and map scale versus accuracy and technical assistance may be appropriate where state, local, or private expertise is available to evaluate floodplain projects on a case-by-case basis. Developing urban areas need map scales of 1"=200' to 1"=400' with one- to four-foot contour intervals. This information should be placed on an orthophoto or topographic base.
- Improved storage of flood data. FEMA should make an immediate and concerted effort to retrieve information gathered for its studies since study contractors may

discard the data after five years. The raw data used in the preparation of existing floodplain maps must not be lost: it may be needed to evaluate individual permits, upgrade maps, or defend floodplain regulations in court. Either the states or the federal government should be the repository for this information.

- Improved dissemination and interpretation of data. Dissemination should be streamlined and increased rather than decreased. The long-term cost effectiveness of the \$900 million already spent on federal mapping will largely depend on the dissemination and interpretation of the data to potential users, including local government, lenders, insurance agents, and developers.

FEMA, OMB, the Corps, SCS, NOAA, and other agencies should continue to improve measures to prevent and respond to flood disasters and to reduce the loss potential of existing uses. Agencies should first identify communities with potential for catastrophic loss of life or property from inland flash flooding, hurricane storm surge and wave action, tsunamis, or other sudden flooding. This identification could be based on existing FEMA flood insurance claims, and disaster assistance information, and National Weather Service data showing areas of high-intensity rainfall. Agencies could then focus mapping, technical assistance, predisaster planning, flood warning systems, and acquisition on these areas. Preflood flood-proofing and relocation could be encouraged through education and insurance incentives. After a disaster, federal teams should prepare hazard mitigation plans (as now required by an OMB directive of July 1980) with state and local assistance. These plans could be implemented through a combination of monies from Community Development Block Grants, FEMA constructive total loss insurance payments, disaster assistance grants and loans, open space funds, and state and local bonds or general revenues.

FEMA, SCS, NOAA, and other agencies should revise and expand education on the severity of flood hazards and the "nuts and bolts"

of hazard reduction techniques. To be effective, education must reach the decision makers. Federal agencies could begin by training their own staffs in Washington, D.C. and at federal regional centers in the specifics of regulation, acquisition, floodproofing, flood warning systems, postdisaster response, implementation of the executive orders, and resource evaluation. FEMA and other agencies could also educate state agency personnel and train engineers, lawyers, and architects. Most training of local officials and landowners should be at the state or local level, but with federal assistance. Agencies could improve landowner awareness by disseminating flood information along with flood insurance policies.

Research

Research to improve the quality and effectiveness of floodplain regulations in the 1980s should focus not only on regulations per se but also on broader techniques of floodplain management.⁶ Research should not duplicate subjects that have already been given adequate treatment such as general floodplain zoning ordinances.

Results, including those of completed research, should be broadly disseminated by all levels of government. The National Science Foundation (NSF), the Corps, SCS, or other federal agencies should fund or carry out supplemental implementation-oriented floodplain management research, with the following topics as priorities.

Establishment and Implementation of a Flood Damage Monitoring System

FEMA, in cooperation with other agencies, should establish a comprehensive federal/state/local flood damage monitoring and reporting system for public and private flood losses. This system should monitor and report on the types and magnitudes of flood damages and public payments to floodplain occupants by type of use, location, method of protection, and other factors. The monitoring program would provide the basis for

readjusting flood insurance rates and determining the effectiveness of various approaches such as elevation on fill and open works, and wet and dry floodproofing.

Evaluation of Flood Loss Reduction Techniques

FEMA, the Corps, NSF, or other agencies should investigate the short- and long-term effectiveness of elevation, flood control, and floodproofing under various flooding frequencies, including rare events such as the 500-year flood. Research should include an analysis of "safety factors" (i.e., the ability of various methods to withstand flooding greater than the design flood). This information would help to evaluate how effective floodplain regulations are in reducing flood losses; establish standards for particularly vulnerable or critical facilities; and establish flood insurance rates reflecting actual risk. Elevation of structures on fill should be compared to elevation on open works and also to floodproofing.

Evaluation of Incentives and Disincentives for Private Self-help

FEMA, OMB, and NSF should carefully examine the incentives and disincentives to private landowners, bankers, and local government officials presented by the flood insurance program, flood control works, disaster assistance, and regulations. Measures should be identified for encouraging self-help by those contemplating building or rebuilding in the floodplain or by those who are modifying structures to reduce flood damage susceptibility.

Identification of Communities with Special Flood Problems

FEMA, in cooperation with other agencies and the states, should make a nationwide analysis of community flood problems so that FEMA, the Corps, USGS, SCS, NSF and other federal and state agencies can tailor federal and state mapping, technical assistance, and other loss-reduction efforts to those communities in greatest need. The analysis should survey⁷

- Cities with chronic flood problems such as Johnstown, Pennsylvania; Houston, Texas; Soldiers Grove, Wisconsin; and Mobile, Alabama, which have been flooded as frequently as once in 10, five or even three years. They are either particularly ripe for corrective action or have already initiated active floodplain management programs. The total number of these communities is estimated to range from 150 to 250. These communities are particularly good candidates for detailed mapping, predisaster planning, training and education, technical assistance, floodplain acquisition, and floodplain monitoring.
- Cities like Jackson, Mississippi; Rochester, Minnesota; and Gulf Shores, Alabama, which had recent severe floods and are faced with flood losses that had been vaguely anticipated in the past but are now presented in stark dimensions. After a disaster there is often a period of at least a few days and at most a couple of years, when the public will support drastic readjustments in floodplain use. The communities in this category change annually. The number of communities suffering a disaster may average 30-100 over several years, but may exceed 500 in a year of major rains combined with rapid spring snowmelt or a major hurricane. These communities are candidates for postdisaster assessments and planning, mapping, technical assistance, floodproofing, and relocation.
- Communities with a high potential for disaster. These include areas like Boulder, Colorado, where planning and civic groups are aware of the prospect of a major disaster but have not experienced one recently. Other areas with continuous potential for disaster include many barrier islands and flash flood regions. The estimated number of these communities is 500 to 1,000. Communities anticipating disaster are prime candidates for predisaster planning, technical assistance, training and education, detailed mapping, flood warning systems, and evacuation plans.
- Partially protected areas. Many communities are partially protected by dikes, levees, and dams, so residents in certain areas assume they are protected from floods of designated magnitude and frequency. Few of these communities have complete protection. Levees and channel improvements can fail. Detention reservoir flows can exceed the projected design flow. Development outside of protected areas may also occur. Inadequate drainage may also cause flood damages within the protected areas. If flooding exceeds design standards, losses may be catastrophic, as in Jackson, Mississippi. Some of these communities are candidates for training and education, predisaster planning, and development of monitoring projects.
- Special flood problems. An estimated 2,000 to 3,000 communities are subject to special flood problems not adequately addressed by NFIP regulations and other standards. These include areas subject to erosion, fluctuating groundwater levels, supercritical inland flows, subsidence, mud flows, and alluvial fan flooding.

Development of Manuals and Ordinances for Specific Flood Problems

FEMA, NOAA, other agencies and states should prepare floodplain manuals and ordinances that deal with special flood problems. A separate manual and model ordinance should be developed for each of the following:

- Inland supercritical flow areas common in the mountain states of the East and West. Manuals should address study techniques, delineation of areas, and protection standards.
- Barrier islands and beach areas. An ordinance or manual should address combined storm surge, wave height and runup, and erosion problems. The manual should explain the natural forces at work, options for dealing with them, and the strengths and weaknesses of each option.
- Flooding behind dikes and levees and below dams, where perhaps one-third of the nation's floodplain structures are located. A description of short- and long-term risks and techniques for dealing with them is needed. The manual should address ponding, evacuation, and perception of risk.
- Alluvial fans and mudslide areas. A discussion of the problems, data gathering needs, sources of data, and regulatory and nonregulatory methods is needed.
- Fluctuating lake levels due to runoff and changes in groundwater levels. The manual should cover prediction of fluctuations and adjustments to problems, including long-term remedies such as relocation.
- Combined wetland protection and floodplain management needs. Assessment of floodplain and wetland natural values, regulations, standards, and options for integrating or coordinating standards should be addressed.

Development of Improved Mapping Techniques

Improved map criteria and cost-effective techniques for generating map data and preparing maps should be developed. Techniques should also be developed for forecasting future runoff in urbanizing watersheds so that flood studies will not become quickly outdated and so that landowners and governments can rely on the long-term accuracy of published elevations. Techniques should also be improved for accurately forecasting coastal erosion recession rates and for establishing setback lines.

In summary, the progress of the 1970s in reducing future flood losses through nonstructural approaches with regulations as one component

must be continued in the 1980s with emphasis on increased specificity and creativity at all levels of government.

CHAPTER VIII

Footnotes

1. Task Force on Federal Flood Control Policy (1966).
2. See Appendix B to this report for more detailed recommendations.
3. See Appendix A to this report for more detailed recommendations.
4. *Id.*
5. Approaches to improve FEMA map criteria and techniques are the subjects of several studies including one by Anderson-Nichols, Inc. for FEMA entitled, "Promising Methods and Procedures for Performing Riverine Flood Insurance Restudies," and one by the National Academy of Sciences now in press.
6. For additional discussion of research needs see National Science Foundation (1980); National Wetlands Technical Council (1979); and White *et al.* (1975).
7. See White (1974).

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