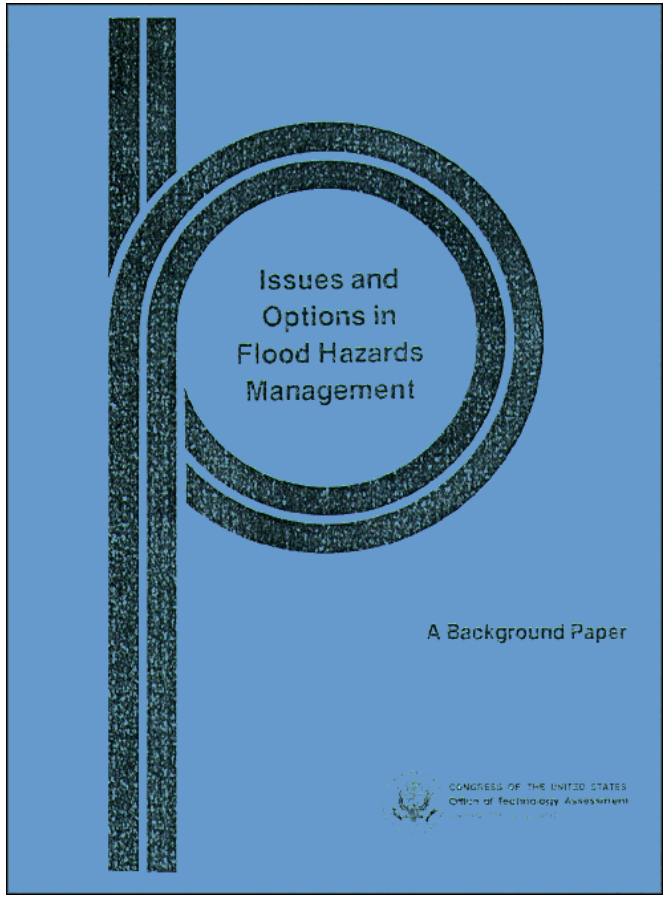
Issues and Options in Flood Hazards Management

February 1980

NTIS order #PB80-151087



Preface

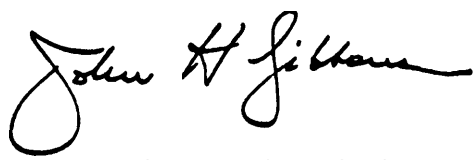
Congressman Thomas L. Ashley, Chairman of the House Committee on Banking, Housing, and Urban Affairs and Senator William Proxmire, Chairman of the Senate Committee on Banking, Housing, and Urban Affairs and member of the Senate Committee on Appropriations, requested that the Office of Technology Assessment (OTA) undertake a study in the area of natural hazards. In response, OTA initiated a preliminary analysis to define what issues are or would be of congressional concern and where further study could be useful.

This Background Paper, "Issues and Options in Flood Hazards Management," is one product of that analysis.

For this study, a working paper was prepared as the basis for a workshop that included a broad representation of interested parties in both the public and the private sectors, scholars concerned with the field, and members of various congressional committee staffs. On the basis of that workshop's recommendations, a revised working paper was prepared and sent to all participants, and to numerous other experts, for extensive review and comment. This paper is the responsibility of OTA, not of those who so ably advised us on its preparation.

An earlier draft of this Background Paper was made available to the staffs of the requesting committees in the winter of 1978-79. Aside from editorial revisions, the principal updating is in chapters VII, VIII, and IX. The basic analysis of information, study, and research needs to assist Congress in policy formulation, legislation, and oversight remains unchanged.

The OTA staff wishes to acknowledge the contribution of the workshop attendees and the subsequent reviewers to "Issues and Options in Flood Hazards Management. " Special appreciation is due Gilbert White of the University of Colorado for his invaluable assistance in the preparation of this paper.



JOHN H. GIBBONS
Director

OTA Project Staff

Joseph F. Coates, Head, *Exporatory Program*
Goldie Hallas, *Secretarial Support*
Terry Saunders Parsons, *Administrative Support*

Consultants

Robert E. Burke H. Crane Miller Rutherford Platt
Renee G. Ford, *Editorial Consultant*

OTA Publishing Staff

John C. Holmes, *Publishing Officer*
Kathie S. Boss Joanne Heming

Invitees to the OTA Workshop on Issues and Options in Floodplain Management and Flood Insurance Washington, D.C. March 21, 1978

Regis Allison
Department of Urban and Community Affairs
Baton Rouge, La.

Charles Anderson
National Association of Home Builders

Arthur Armstrong
Director, Office of Finance
Small Business Administration

Edgar Armstrong
Director of Insurance Protection
American Bankers Association

John Banta
Conservation Foundation

Tom Barlow
Natural Resources Defense Council

Richard Boisvert
Federal Insurance Administration

James Brown
National Law Center
George Washington University

Al Carrillo
Assistant National Liaison Officer
National Red Cross

Kenneth Christenson
Senior Operations Officer
Defense Civil Preparedness Agency

Robert A. Clark
Associate Director for Hydrology
National Weather Service

Charles Culver
Disaster Research Coordinator
Center for Building Technology
National Bureau o/Standards
Department of Commerce

Walter Curtner
Johns Manville

Russell R. Dynes
Executive Officer
American Sociological Association

Glenn Flittner
Chief of Oceans Studies
National Weather Service

Charles Fritz
Executive Secretary
Committee on Socio-Economic Effects of Earthquake Prediction
National Research Council

Charles Fritzel
National Association of Independent Insurers

James Goddard
Consulting Engineer

Herbert Groper
Acting Chief
Disaster Preparedness Staff

Jerry Harbour
Chief, Site Safety Research Branch
Office of Nuclear Regulator Research
Nuclear Regulatory Commission

Michael Helpa
Chief of Emergency operations
Office of the Chief of Engineers

C. Robert Hall
National Association of Independent Insurers

Dwight Ink
Director, Office of Sponsored Research and Continuing Education
School of Public Affairs
American University

D. Earl Jones, Jr.
Chief, Field Services Branch
Office of Technical Support
Department of Housing and Urban Development

Erie Jones
Director of Emergency Services
State of Illinois

George Jones
Coordinator
Office of Emergency Services
State of Virginia

Richard W. Krimm
Assistant Administrator
Federal Insurance Administration
Department of Housing and Urban Development

Howard C. Kunreuther
The Wharton School
University of Pennsylvania

John Kusler
Consultant

Nicholas Lally
Federal Insurance Administration
Department of Housing and Urban Development

Richard Leisker
Director for Emergency Loan Division
Department of Agriculture

Herbert Lieb
Chief of Disaster Planning
National Weather Service

Jim Lewis
Federal Disaster Assistance Administration
Department of Housing and Urban Development

Charles Manning
Council of State Governments
Emergency Preparedness Project

J. McGoldrick, Jr.
Chairman
Massachusetts Mutual Life Insurance Company

Joseph Mitchell
Director
Federal Preparedness Administration
General Services Administration

Roy Newsome
Special Assistant to the Administrator
Federal Disaster Assistance Administration
Department of Housing and Urban Development

Clark Norton
Congressional Research Service
Library of Congress

Frank Nutter
National Flood Insurance Association

George Phippen
Floodplain Management Services In the Directorate of civil Works
Office of the Chief of Engineers

Roy S. Popkin
Assistant National Director of Disaster Services
National Red Cross

E. L. Quarantelli
Disaster Research Center
The Ohio State University

Susan Sarason
Clean Water Action Project

Terry Sopher
Regional Environmental Management
National Science Found anon

Charles C. Thiel
Director, Division of Problem-Focused Research Applications
National Science Foundation

Frank Thomas
Water Resources Council

Charles Thurow
Association of State Planning Officials

Bardyl Tiranda
Director
Defense Civil Preparedness Agency

David Tundermann
Council on Environmental Quality

Jack Warner
American Institute of Architects Research Corporation

Samuel Weese
General Manager
National Flood Insurance Association

French Wetmore
Chief, Local Flood Plain Programs
Department of Transportation

Gilbert White
Center for Natural Hazards
University of Colorado

Hilary Whittaker
Project Director
National Governors' Association for Emergency Preparedness

John Wiggins
J. H. Wiggins Company

Richard Wray
office of Finance
Small Business Administration

Arthur Zeizel
Environmental Scientist
Office of Policy Development & Research
Department of Housing and Urban Development

Congressional List

Kenneth Ackerman
Office of Senator Charles H. Percy

Martha Braddock
Senior Staff Member
Senate Committee on Banking, Housing, and Urban Affairs

Anne Cheek
Office of congressman Jack Brinkley

Elmer Henderson
Staff Director of Subcommittee on Legislation and National Security
House Committee on Government Operations

Thomas Kraemer
House Science and Technology Committee

David Johnson
Staff Member
Senate Committee on Government Affairs

Jack Lewis
Office of Senator Thomas F. Eagleton

Robert E. Malakotf
Staff Director
Subcommittee on Housing and urban Affairs
Senate Committee on Banking, Housing, and Urban Affairs

Richard N. Ma low
House Committee on Appropriations

Gerald McMurray
Staff Director
Subcommittee on Banking, Currency, and Housing
Senate Committee on Banking, Housing, and Urban Affairs

Mike McNulty
Staff Member
House Committee on Interior and Insular Affairs

Judy Parente
Senate Committee on Environment and Public Works

Kevin Phelps
Office of Senator Quentin Burdick

Clem Shearer
Office of Hon. George E. Brown, Jr.

Ricki Tigert
Subcommittee on Citizens Rights
Senate Committee on the Judiciary

Thomas van der Vort
Senate Committee on Appropriations

OTA Consultants

Robert E. Burke

H. Crane Miller

In addition to comments received from the above workshop invitees and participants, we would like to express our appreciation to the following reviewers:

George Antle
Institute for Water Resources

Maurice Arnold
U.S. Department of the Interior

Charles Belt
St. Louis Unversity

Sally Davenport
Texas Coastal and Marine Council

Ronald Davis
Consultant

Jerry Delli Priscolli
Institute for Water Resources

Henry Hitchcock
George Washington University

Richard Liroff
Environmental Law Institute

William Onopa .
Office of the Governor, State of Arkansas

H. James Owen
Consulting Engineer

Robert Rigney
County of San Bernardino (Calif.)
Environmental Improvement Agency

Paul Slovic
Decision Research

William Wilcox
Federal Disaster Assistance Administration

Acronyms

CZMP —coastal zone management program
DOT – Department of Transportation
EDS — Electronic Data Services
FEMA —Federal Emergency Management Agency
FHA — Federal Housing Administration
FIA — Federal Insurance Administration
FIRM – flood insurance rate map
HEW — U.S. Department of Health, Education, and Welfare
HUD – Department of Housing and Urban Development
IWR — Institute of Water Resources (U.S. Army Corps of Engineers)
NFIA —National Flood Insurers Association --
NFIP —National Flood Insurance Program
OCZM —Office of Coastal Zone Management
P&s — principles and standards
TA — technology assessment
VA — Veterans Administration
WRC – Water Resources Council

Glossary

common use open space: lands set aside for public use and management by acquisition, as contrasted to those held open by ordinance provision (e.g., a floodway) that remain in private ownership.

cost-benefit analysis: a systematic economic comparison of alternative ways to achieve an objective.

enabling statute: a State law that transfers some of the police power residing in the State to localities within it for the purposes of zoning, subdivision, regulations, building codes, and the like.

encroachment: the occupancy of areas subject to flooding, especially where such occupancy includes landfills and buildings.

flood: an overflow of lands not normally covered by water and that are used or usable by man. Floods have two essential characteristics. These are: 1) the inundation of land is temporary, and 2) the land is adjacent to and inundated by overflow from a river or stream or an ocean, lake, or other body of standing water.

flash ***flood:*** a flood that follows the causative event (this might be excessive rains, a dam failure, etc.) within a few hours. The rise in runoff and stream levels is spectacular and produces hydrography traces that reflect an extreme jump in discharge volume.

100-year ***flood:*** a flood having an average frequency of occurrence in the order of once in 100 years although the flood may occur in any year. It is based on statistical analyses of streamflow records available for the watershed and analyses of rainfall and runoff characteristics in the general region of the watershed. This term is used in the National Flood Insurance Program to indicate the minimum level of flooding to be used by a community in its floodplain management regulations.

hazard adjustment: see structural and nonstructural flood plain management measures.

flood insurance rate map (FIRM): an official map of a community on which the Federal Insurance Administration has delineated both the special hazards areas and the risk premium zones applicable to the community.

floodplain: an area adjoining a river, stream, arroyo, or other watercourse, ocean or lake, or other body of standing water that has been or may be covered by floodwater. It includes, at a minimum, that area subject to a 1 percent or greater chance of flooding in any given year.

floodway: the channel of a river of other watercourse, and the adjacent land areas, required to carry and discharge a flood of a given magnitude without increasing the water surface elevation at any point more than a specified amount and without producing hazardous velocities. The floodway component of a flood insurance study indicates the portions of a floodplain that could be obstructed without increasing the water-surface elevation of the 100-year flood more than 1 foot at any point.

flood profile: a graph showing the relationship of water surface elevation to location. It is generally drawn to show surface elevation for the crest of a specific flood but may be prepared for conditions at a given time or stage.

fringe (or flood fringe): is normally considered to be that portion of the floodplain between the floodway and the natural outline of the selected flood.

hazard adjustment: see structural and nonstructural floodplain management measures.

institutional question: one that arises from the body of rules, procedures, and authorities under which governmental institutions function.

National Flood Insurance Program: the program under which communities may be eligible for federally subsidized flood insurance on the condition that the communities enact satisfactory floodplain management regulations.

Emergency Program: the program as implemented on an emergency basis in accordance with section 1336 of the Act. It is intended as a program *to* provide a first layer amount of insurance on all insurable structures before the effective date of the initial flood insurance rate map (FIRM).

Regular ***Program:*** the program authorized by the Act under which risk premium rates are required for the first half of available coverage (also known as "first layer" coverage) for all-new construction and substantial improvements started on or after the effective date of the FIRM, or after December 31, 1974, for FIRM's effective on or before that date. All buildings, the construction of which started before the effective date of the FIRM, or before January 1, 1975, for FIRM's effective before that date, are eligible for first layer coverage at either subsidized rates or risk premiums rates, whichever are lower. Regardless of date of construction, risk premium rates are always required for the second layer coverage and such coverage is offered only after the Administrator has completed a risk study for the community.

natural disaster: an extreme case of the realization of a risk.

natural hazard: an environmental or natural circumstance that is a source of danger.

nonstructural floodplain management measures: the nonphysical measures employed to modify the exposure of people to floods, i.e., land use planning, warning schemes, and insurance.

opportunity cost: monetary or other advantage surrendered from something in order to acquire it in competition with other potential users.

risk: the works of man (and man himself) that are endangered as a consequence of their exposure to a natural hazard.

riverine: relating to, formed by, or resembling a river (including tributaries), stream, brook, etc.

seiche: a standing wave oscillation of an enclosed water body that continues, pendulum fashion, after the cessation of the originating force, which may have been either seismic or atmospheric. Tides are now considered to be seiches induced primarily by the periodic forces caused by the sun and moon. In the Great Lakes area, any sudden rise in the water of a harbor or a lake, whether or not it is oscillatory is a seiche.

storm:

storm surge: a super elevation of water surface by storm pressure as in a hurricane, i.e., the height above the expected level in the absence of storm conditions.

30-year ***storm:*** (meteorological) an artifact of -- the statistical averaging of storm experience. This should not be confused with a 30-year flood, which could come about as a result of lesser or greater storms.

structural floodplain management measures: those physical or engineering measures employed to modify the way floods behave, e.g., dams, dikes, levees, channel enlargements and diversions.

taking issue: a possible basis for suit when an individual asks to be recompensed for lost property value resulting from governmental action as is his right under the Constitution. Government cannot take property without just compensation. However, a mere diminution of value is not necessarily a taking. Courts have upheld ordinances in cases where the governmental action resulted in substantially lower market values, and even some cases where all the recognizable economic values disappeared because the only economic uses remaining would be regarded legally as a nuisance or threat to public health and safety.

tsunami: is a system of free-surface gravity waves generated by a submarine earthquake or volcanic eruption. Although the term "seismic sea wave" adequately describes such an event, the Japanese word "tsunami" is now almost universally accepted in the scientific community. Its literal translation is "harbor ('tsun') wave ('nami')."

velocity zone: the portion of a coastal floodplain having special flood hazards, which is subject to high velocity waters especially waves—from hurricanes, tsunamis, and extratropical storms.

watershed: all the area contributing runoff to the flow of a river or draining into a body of water. Also sometimes, the margins of this area.

wetlands: land containing much soil moisture, such as tidal flats or swamps.

Contents

chapter		Page
L	Executive Summary	1
	The Approach	1
	Summary	1
	Policy Options	7
11.	Introduction	11
m.	Floods: A National Policy Concern	13
	The Physical Bases of Floods	13
	The Geographic Scope of Floods	14
	The Costs of Floods	14
	Elements of National Response	23
lv.	A Framework for Flood Hazards Management	27
	The Lifecycle of a Flood Hazard Warning	27
	Warning	30
	The Time Frame of Public Policy Planning and Implementation	30
	Tools Available for Flood Hazards Management	31
	Beyond Calculating Costs and Benefits	34
v.	Trends and Images of the Future	39
	Trends Directly Related to Floods	39
	Trends Related to Natural Hazards	41
Vl.	The Issues	43
	Public Policy Issues	43
	The Issues in Flood Hazards Management	43
Vll.	The National Flood Insurance Program	47
	Origins of the Program	47
	The Present Program	48
	What NFIP Has Accomplished	52
	Some Recent Studies of Flood Insurance	53
vm.	Flood Insurance Issues	57
	Reorganization–Transfer to FEMA	57
	Intergovernmental Relations	57
	The Emergency Program	60
	Coastal Hazards and Erosion	62
	Postdisaster Recovery and Mitigation	62
	Government as Salesman and Agent for Technology Transfer	63
Ix.	Legal Aspects of Floodplain Regulation in the 1970's	65
	Introduction	65
	The Judicial Recognition of Flood Hazards	66
	Inland and Coastal Wetlands Restrictions: Indirect Floodplain Management	69
X.	The Roles of Federal, State, and Local Governments	73
	Federal Roles	73
	The Role of the States	76
	The Role of the Local Government	76

Contents—continued

chapter		Page
XI.	Knowledge Gaps and Research Needs	79
	Why Research?	79
	What Is Currently Known With Respect to Flood Hazards Management?	79
	Knowledge Gaps in FloodHazards Management	80
	Policy Research Priorities	81
XII.	Some Policy Options	89
	Setting Goals	89
	Land Use Management	89
	A Federal Opportunity: Leadership by Example	89
	The Flood Insurance Program as Hazards Manager	90
	An A1l-Hazards Approach to Insurance	90
	The Mission of the Corps of Engineers,	91
	Mapping Delays and Alternative Entry Policies	91
Appendixes		
A.	Coastal Erosion	93
B.	Executive Order 11988	95

LIST OF TABLES

1.	Policy Research and Study Needs in Relation to Congressional Functions	8
2.	Frequency and Cause of Flooding Between 1886 and 1972 in the New York State Counties of Livingston, Steuben, and Chemung	17
3.	Exposure to Floods of Selected Urbanized Areas	18
4.	Losses in Individual Severe Floods in the United States Since July 1902	20
5.	Annual Property Loss Attributable to Floods	21
6.	Flood History of Rapid City, S. Dak.	23
7.	Chronology of Major Flood and Public Response	32
8.	Governmental Strategies and Tools for Flood Hazards Management	32
9.	Relevance of Nonstructural Measures to Floodplain Management Objectives	33
10.	Means or Policy Options in the Implementation of Nonstructural Measures	36
11.	Identification of Costs by Sector	36
12.	Identification of Benefits by Sector	42
13.	Trends in Relation to Natural Hazards in the United States	44
14.	Seven Issues in Flood Hazards Management Summarized	50
15.	Growth of Coverage Under the National Flood Insurance Program	51
16.	Community Progression in the National Flood Insurance Program	54
17.	Individual Perception of Flood Damage	55
18.	Flood Insurance: Residents and Businesses Through 1977	56
19.	Patterns of Flood insurance Purchase in 43 Pennsylvania Communities	75
20.	Federal Elements in Floodplain Management	82
21.	Funding Levels for Research Opportunity Sets	83
22.	Research Opportunities-Hurricanes	85
23.	An International Comparison of Flood Hazards: Canada	93
A-1.	Research Opportunities-Coastal Erosion	

LIST OF FIGURES

1.	Lifecycle of a Flood Hazard	3
2.	Most Flood-Prone Areas of the United States	15
3.	Map of Southern New York State Indicating the Flood-Prone Counties of Livingston, Steuben, and Chemung	16
4.	Losses in United States Floods, 1905-72	19
5.	Lifecycle of a Flood Hazard	28
6.	The Complexity and Confusion of Federal Responsibilities	29
7.	National Flood Insurance Program's History	49

1. Executive Summary

This preliminary analysis has two purposes: to identify information and knowledge gaps in the management of flood hazards, and to propose some policy options for further consideration that could beneficially affect such management.

THE APPROACH

Five basic elements are involved in meeting the above purposes.

- Determining long-term trends in relation to floods and flood hazards management.
- Identifying issues—the points of enduring conflict.
- Proposing the lifecycle of a flood hazard as a diagnostic and prescriptive framework for policy study.
- Identifying knowledge and information gaps.
- Proposing several policy options.

SUMMARY

Floods as a Policy Concern

Every year, flood disasters, which include hurricanes, flash floods, mudslides, subsidence, river valley floods, and winter coastal storms cause hundreds of deaths and result in property losses of about $2 billion. Some recent examples are:

- the 1972 Agnes floods— 105 lives and over $4 billion in damage;
- the 1972 Rapid City, S. Dak., flash flood —237 lives and over $164 million in damage;
- the 1973 Mississippi Valley floods-33 lives and $1.15 billion in damage;
- a 1974 flash flood in Colorado's Big Thompson Canyon, which destroyed virtually everything in its path— 123 lives.

The Federal Disaster Assistance Administration reports flood-related assistance expenditures of $872 million between 1974 and October 1978.

Despite an estimated $14 billion spent by the U.S. Army Corps of Engineers and other Federal agencies for structural flood control projects since 1936, losses have continued to rise. Concomitantly, Federal disaster assistance payments have increased sharply from $52 million in 1952 to an all-time high of '$2.5 billion in 1973. These dollar figures, however, only represent a small fraction of the total social costs of dislocations due to floods.

In vulnerable areas, urban expansion into floodplains and coastal hazard areas has been estimated to increase flood losses an average of 1.5 to 2.5 percent per year. This represents roughly a doubling of investment risk in one generation.

Urbanization and other changes in land use contribute to the frequency and intensity of floods. As permeable natural surfaces give way to roofs, pavements, and sewer development, rainfall and snowmelt are channeled directly to streams instead of soaking into the ground. In one watershed north of Boston, the estimated 100-year flood (having a l-percent chance of occurring in a given year) became a 20-year flood (5-percent chance) within the course of 15 years of rapid development. This, of course, applies to development anywhere in the watershed, not simply in the floodplain.

Any strategy for coping with flood losses must contend with the fragmentation of political and legal authority over the Nation's river basins and floodplains. Rivers and streams typically flow from one jurisdiction to another, and frequently are used as convenient boundaries between local governments, counties, and States. Actions in one jurisdiction may affect other jurisdictions downstream, across the stream, or even (in the case of backwater flooding) upstream. Individual encroachments on floodplains cause cumulative impacts in the form of increased flooding in neighboring areas. Yet, land use and floodplain policy has been viewed as largely a local matter. Floodplain management, therefore, has proceeded on a parochial and fragmented basis, ill-suited to the achievement of national or local flood loss reduction.

The National Flood Insurance Program (NFIP), since its inception in 1968, and strengthened by substantial amendments in 1973, has become the major new instrument in national flood policy. It

reflects the recent emphasis on a mixed-strategy approach.

The actual effect of NFIP on flood losses is questionable. Specifically, the program involved both the sale of federally subsidized flood insurance, and the management of floodplains by non-Federal public authorities. The insurance without floodplain management could lead to the increased development of flood hazard areas. This would drive flood losses still higher. At present, the management component of NFIP lags far behind the sale of insurance. Consequently, a special effort will be required to attain the floodplain management goals of NFIP.

A Framework for Flood Hazards Management: The Lifecycle of a Hazard

Flood hazards, like other natural hazards, have their origin in nature. F1ood disasters, however, are a consequence of the intrusion of man and his works into an environment that puts them both at risk.

An effective management strategy for moderating a flood hazard, or any other natural hazard, must take into account the hazard's total lifecycle as it evolves from its natural condition in an environment into the risk conditions created by the people's activities in that environment. The lifecycle shown in figure 1 presents an overall picture from which the relative strengths and weaknesses in current public policy can be identified.

At present, the relatively strong capabilities of flood hazards management are its emergency organization and its planning for dealing with the immediate postdisaster situation (items 6 and 14 in figure 1). The readiness to exercise an emergency response (item 15) is a much weaker capability. Damage assessment (item 17) is relatively well-done after minor floods but much less so after major floods in most areas.

Planning for rehabilitation and recovery (item 18) is seriously deficient in all areas subject to floods. For maximum effectiveness, comprehensive plans to provide relief, as well as rehabilitation, must be readied before a disaster strikes. The only long-term strategy that will reduce future flood disasters is to rebuild properly designed structures on suitable sites, avoiding the repetition of past errors. At the present time, however, without proper planning for rehabilitation and recovery after a major flood, it is not likely that the unsound building patterns of the past will be changed.

Prevention has traditionally relied on controlling floods by means of civil engineering works. The increasing inadequacy of civil works that are not closely tied to land use planning is widely recognized. For this reason, how to make long-term land use planning an effective tool for controlling development in flood hazard areas and for guiding postdisaster recovery is a principal public policy question in flood hazards management. Without effective means for controlling floodplain development and guiding postdisaster recovery, the cost of floods nationwide will continue to rise.

Three Basic Approaches to Flood Hazards Management

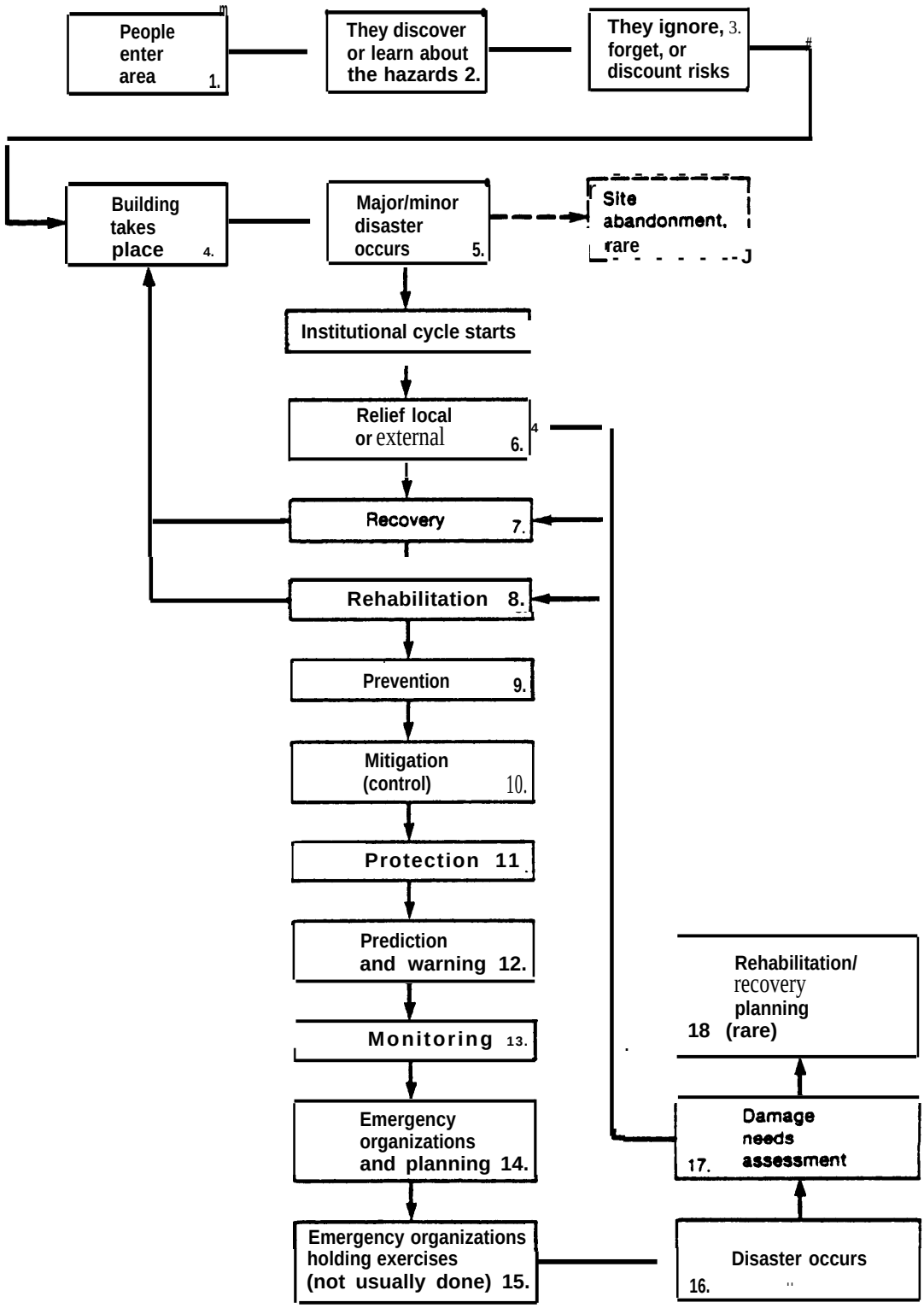
The U.S. Water Resources Council in its 1976 policy statement, "A Unified National Program for Floodplain Management" (revised in 1979), assigns all possible public responses to flood hazards to three basic approaches:

- Modify flooding itself by using structural controls to alter the course or flow of the water.
- Moderate the impacts of flooding on individuals and communities through insurance, disaster relief, and tax adjustments.
- Reduce the risks of flood damage.

The traditional approach to flood hazards at the Federal, State, and local levels has primarily been to modify the hazard. Flood control dams and reservoirs may influence the volume of runoff during peak stages of a flood and consequently affect when a flood occurs and its duration, as well as the extent of area flooded. Within the limitation of their design capacity, levees and dikes can protect certain downstream areas from floods. But both types of structures affect the natural flow of streams, thus increasing erosion and sedimentation, and impairing natural habitats and ecological processes. Furthermore, as noted above, flood losses continue to rise despite the major national investment in flood control. One reason is that it is unfeasible to build works that will protect against every conceivable flood. When the design limits are exceeded, catastrophic losses may be inflicted on settlements originally attracted to the floodplain in the belief that it was protected.

Two other traditional approaches to flood hazards are emergency measures including flood warnings and temporary removal of property, and

Figure 1-Lifecycle of a Flood Hazard



SOURCE. Office of Technology Assessment.

disaster assistance. Again, it is recognized that the consequences of floods cannot be effectively dealt with by these measures alone. The most that can be achieved through warning schemes is saving a few lives and slightly reducing property loss. Disaster relief encourages continued occupancy of unsafe locations.

The approach to the management of flood hazards is shifting toward measures that would reduce the susceptibility to flood damage by integrating land management techniques, such as restricted occupancy, with the traditional tools and strategies, such as civil works. Emphasis is being placed increasingly on zoning codes, regulations, the implementation of development and redevelopment plans, and policies to improve the design and the location of structures.

Trends Related to Flood Hazards

Trends analysis is useful in at least three ways. It defines the boundaries on alternative future developments; it forces one to search for underlying factors that may either stabilize or perturb the trend; and it suggests opportunities for policy intervention to modify what would be a stable but undesirable development.

Trends that will shape the future of exposure to flood hazards in the United States fall into four categories:

- the degree of risk posed by floods,
- Ž the effects of demographic trends on flood hazards,
- Ž evolving patterns of floodplain use, and
- trends in public policy responses.

Trends related to flood risk.–The most important risk-related trend is that public policies, by continuing to encourage floodplain development, are causing losses to continually rise and may cause catastrophes of unprecedented scale. The number of lives lost in these potential major events could easily be in the thousands and property loss could amount to billions; far exceeding any previous experience.

The loss of life from floods, while low compared with that of developing countries, has shown a slight upward trend over the past several decades. Property loss has grown. It is not clear how much the effect has been of true increases, inflation, better reporting schemes, insurance availability, or other factors.

Compounding the problem created by increased urbanization of floodplains, watershed flooding itself is increasing. As natural surfaces are covered by impermeable-roofs and pavement, runoff increases and floods are magnified in frequency and intensity. "Acts of God" are a decreasingly important aspect of flood hazards. As an understanding of the causes and prevention of flood losses increase, the responsibility for such losses inevitably must shift from unanticipated events to people's disregard of the known facts, along with their reluctance to plan.

There is a downtrend in the original historical reasons for the occupancy of floodplains. Proximity to bodies of water is normally no longer required for energy, water supply, waste disposal, and transportation. The growth of the highway system, pipelines, railroads, electric utility grids, and other similar infrastructures has virtually eliminated the economic need to locate next to rivers and streams. However, water resources and adjacent areas are increasingly the subject of conflict over alternative uses and allocations. Among the competing forces presently involved in the use of floodplains are commercial and industrial development, housing, the growth of outdoor natural and commercial recreation areas, the desire for the conservation of natural resources-especially in wetlands—and historical preservation. There is more legislation today than in the past that relates to floodplains and coastal zones.

Demographic trends.–Flood hazard potential is, in part, increased by the continuing migration of population to coastal areas on both a seasonal and permanent basis. Between 1960 and 1970, coastal counties of the United States gained 20 percent in population as compared with a 14-percent gain for the Nation as a whole. This trend is believed to be continuing. In most riverine floodplains, the number of people is less important than the expansion of investment in nonresidential property. However, there is evidence of continued development of mobile home communities and lower cost, vulnerable housing in marginal floodplain locations.

Space for building to meet a growing population is fast disappearing in areas with mountainous terrain such as West Virginia, and in sites of heavy industrial development. Where there is a need to be near the workplace, development of marginally hazardous areas tends to be promoted. Development pressure coupled with recreation demands

has increased the number of residences and people exposed to floods, especially in coastal recreation areas. Furthermore, the elderly and other retirees are moving to warm coastal climates, often unaware of the natural hazards risks they may be facing.

Trends in the management of flood hazards.–From 1936 to 1968, the prevailing national response to flood hazards was to undertake flood control projects, largely.at Federal expense. Since the 1966 Report of the Task Force on Federal Flood Control Policy (House Document 465), several trends have led to challenging the primacy of flood protection by physical methods as the chief public approach to dealing with flood hazards.

There is a shift in emphasis from "structural," or engineering, measures such as dams to moderate losses, to "nonstructural" economic sanctions and incentives. These latter are adopted instead, or in addition to, physical measures. Together they achieve what the Task Force on Federal Flood Control Policy termed a "unified program for managing flood losses. " Implementation of mitigation, prevention, and loss reduction measures at local levels is being emphasized as a precondition for the receipt of Federal disaster relief. Such nonstructural measures as floodplain zoning, building and design controls (e.g., minimum elevation requirements), and acquisition and relocation are being increasingly applied. The last, however, has not proven practical owing to the lack of consistent and timely Federal cost sharing. There is also a growing trend to view land use planning as an essential tool of flood hazards management.

Lastly, there is a trend toward the use of flood insurance as an alternative to outright disaster relief. Through insurance premiums calculated to reflect the extent of flood hazard at a particular location and elevation, it is intended that voluntary private decisions will act to minimize exposure to flood loss.

issues in Flood Hazards Management

The issues or conflicts in flood hazards management fall into seven major areas.

Equity issues.–There are two **key** equity issues. The first finds the right of property owners to the unrestricted use of their property in conflict with governmental responsibility to safeguard health, safety, and the welfare of citizens. The second involves the distribution pattern of costs and benefits from the mitigation of flood hazards and from disaster relief. The central question is whether the distribution should principally involve all local payers and beneficiaries or should cover a broader national base.

State and local government versus the -- Federal Government.–The conflict between Federal and non-Federal public authorities flows from two considerations. The first reflects the constitutional limitation on federalism and the distribution of sovereign power among Federal, State, and local governments. The second reflects the piecemeal, contradictory, and poorly integrated plans and programs of the Federal Government in dealings with State and local governments.

Integration of Federal programs.–There is . little integration within the Federal system in terms of agency plans and programs concerned with flood hazards management. This may be improved by the President's reorganization of Federal agencies responsible for hazards and emergency preparedness.

Goal conflicts. -Goal conflicts arise from two sources. First, there are no action-oriented national goals with regard to flood hazards management. Second, existing programs that are directed at dealing with flood hazards areas are disorganized and at cross-purposes.

Means conflicts.–The traditional means of flood control are increasingly seen not only as inadequate but also as methods that cause the situation to worsen. Yet, political, social, and institutional conflicts are inherent in any transition to an integrated approach using nonphysical or socioeconomic strategies along with physical or engineering design strategies.

Short-term versus long-term interests.–The short-term benefits of development in hazardous terrain conflict with the longer term risks. In addition, conflicts arise over the calculations of short- versus long-term costs and benefits.

Information.–Information about all aspects of flood hazards is inadequate. A policy information base is not available and there is a reluctance to generate it. Research programs are uncoordinated and information is not disseminated in a useful and timely form to all concerned. (Information needs particularly relevant to policy development are discussed in chapter XI.)

The National Flood Insurance Program

The National Flood Insurance Program (NFIP) seeks to promote two interrelated objectives in the Nation's coastal and riverine flood hazard areas:

- To stabilize and eventually reduce flood losses by stimulating the planning and management of flood hazard areas by States and local governments.
- To reallocate the costs of financial assistance to flood victims from Federal taxpayers to occupants of flood-prone areas through the mechanism of insurance.

These are related goals. Effective management of floodplains will keep future losses from continuing to rise; while the intent of establishing a federally sponsored flood insurance program is to reinforce the management of floodplains by setting insurance premium rates for new structures according to the risks at specific sites.

The Accomplishments of the Federal Insurance Administration (FIA)

A number of positive achievements can be cited for NFIP.

- The Flood Disaster Protection Act of 1973 amended NFIP to provide for compulsory participation and emergency eligibility.

  This succeeded in establishing the insurance as a standard feature of Federal flood policies, as evidenced by the approximately $67.3 billion in insurance coverage held by over 1.7 million policyholders.
- Progress is being made towards achieving the national objective of completely mapping about 20,000 flood-prone communities by 1983. The preliminary mapping has so far informed some 19,000 local governments about their flood hazards.
- Building codes and practices in many flood-prone communities have improved.
- The delineation of the Nation into flood-prone areas has stimulated public awareness of flood hazards.
- The program is stimulating the purchase of flood insurance.
- The state-of-the-art has improved in such pertinent subject areas as home construction, economics, environmental engineering, hydrology, and hydraulics.

Flood Insurance Issues

NFIP is confronted by a number of issues whose resolution would greatly accelerate the achievement of its objectives. These issues deal with the following problems:

- *Reorganization*— By executive order, FIA has been reassigned to the new Federal Emergency Management Agency (FEMA). The purpose of this reorganization is to place Federal emergency mitigation and response activities in one agency and to provide "one-stop" service to States and local governments.
- *Coordination within the Federal Government*—Collaboration between FIA (especially as part of FEMA) and other Federal agencies such as the Office of Coastal Zone Management and the Environmental Protection Agency needs to be improved in order to more effectively pursue mutual goals.
- *Intergovernmental relations—Coordination* must be improved between public units, both vertically (Federal, State, regional, and local) and horizontally (between adjoining units of government).
- *Premium rates and* equity—As more communities enter the regular program of NFIP, the actuarial rates must be set accurately and fairly.
- *Coastal* hazards-NFIP flood studies must reflect wave heights. Flood insurance should be withheld entirely in the velocity zone (V). Recognition of erosion hazards should be improved in NFIP mapping and regulations.
- *Postdisaster mitigation—Section* 1362 of the National Flood Insurance Act of 1968 should be implemented. Postdisaster recovery planning should be required to provide for mitigation of hazards through land acquisition and relocation.
- FIA has assumed direct responsibility for the marketing of flood insurance in addition to its commitment to provide technical assistance on floodplain management.

Knowledge Gaps and Research Needs

The purpose of this report is to identify what information is needed, which, if provided, will assist Congress in policy formulation, legislation, budget allocations, and oversight on flood hazards management. There are five main areas where additional knowledge is needed:

- the generation of information,
- the transmission of information,

Ž the utilization of information,
Ž the effectiveness of already established hazards-related programs, and
. information gaps in NFIP.

Generation of Information.–Federal disaster research needs to be coordinated. There is no procedure for identifying information needs for policy setting, program planning, land use management, and engineering design utilization.

- The means are inadequate for identifying and transmitting State and local information needs to the Federal agencies.
- There is no mechanism for determining what needs to be known to improve flood hazards management.
- There are not enough first-rate researchers in the field due to the lack of steady and adequate support, and because there is no sense of urgency on the part of the Federal Government.

Transmitting information.–There is no single source for data and information produced by the various Federal agencies that deal with flood hazards. Until recently, there has not been any focus on transmitting information about hazards. This could be accomplished by the newly established FEMA.

- At present, no criteria have been established for determining the relative value, success, or failure of research projects.
- The functions of the various components of a delivery system. Who should be transmitting information to whom; and in what form? These questions are all unanswered at the Federal agency level.
- Information about the potentials of flood hazards is not well disseminated, either to the public or to public officials and organizations, owing to the lack of coordination among Federal agencies.

Utilization of information.– " '

- The criteria for determining whether there has been a discernible impact on the decision processes of individuals and organizations, have not been established.
- In what way does the utilization of information differ from its dissemination and transmission?
- The absence of programing and policy goals and the lack of a client orientation undercuts attempts at utilization.

Information gaps in NFIP.–NFIP plays a significant role in flood hazards management, therefore particular note is made of inadequacies in its information base.

- Who purchases flood insurance and for what reasons? ...
- Which communities drop out of the program, and why?
- How can the Federal agencies relate better to local needs?
- Who at the local level is responsible for identifying the needs and making plans for their local communities?
- How much new construction is going on in floodplains during the emergency program?

Study and research projects to fill the above gaps in knowledge, and their relationships with the four congressional functions of policy formulation, legislation, budget allocation, and oversight are shown in table 1.

POLICY OPTIONS

This report sets forth some suggested policy options for improving the management *of flood* hazards. These options are not recommendations, but proposals for further consideration. They fall into seven categories.

Setting Goals

The absence of goals specific enough to guide change and *to evaluate* progress acts as a major impediment to achieving an integrated strategy for flood hazards management. Three alternative, but not exclusive, goals are suggested below that would allow standards of accomplishment to be defined and evaluated.

- Hypothetical goal I.–The national objective over the next 10 years is to put flood insurance on a fully actuarial basis.
- Hypothetical goal 2.—National policy is that over the next four decades population and physical investments in floodplains at the 100-year risk level shall be reduced by 80 and 70 percent, respectively.
- Hypothetical goal 3.–The annual losses from floods as part of a national program shall be reduced by 25 percent per decade (in 1975 dollars)

Table I.-Policy Research and Study Needs in Relation to Congressional Functions

Budget

- use of remote sensing and other advanced data collection techniques
- study of the 25- to 50-year cost implications of:
  - —insurance without regulation
  - —acquisition of flood lands
  - —alternative management strategies
- Ž general cost-effectiveness of alternative mitigation techniques
- . cost-effectiveness of warning systems
- funding of implemental ion programs for warning systems in small towns

Policy

- reassessment of the efficacy of the 100-year flood guideline, and study of the implications of alternative standards
- a handbook of maximum credible flood disasters in each flood-prone region of the United States
- development of options for local governments to accumulate disaster "war chests"
- preparation of manual for States to learn cost-effectiveness of different flood strategies
- a comprehensive guidebook to Federal grants, assistance in all aspects of disaster planning, response, and rehabilitation

Legislatlon

- . integration of flood hazards with management of other hazards
- further use of the "unified national program" approach to identify operational steps for converting concepts into programs and projects
- . integration of flood warning with other natural and man-made hazards warning and information systems
- study of the existing authorities of the agencies, police powers, the "taking issue," and tort liability of the design and structure professions

Oversight

- case histories of successful and unsuccessful flood management strategies
- alternative modes of information delivery
- effects of specific Federal predisaster, disaster, and postdisaster actions on floodplain management
- alternative decisionmaking arrangements for setting plans and for the regulation of the floodplain
- the perception, interpretation, and use of risk information by the public-at-large
- analysis of the long-term geophysical and environmental phenomena related to floods
- review of foreign experience pertinent to U.S. situation
- National Flood Insurance Program:
  - —actuarial future
  - —subsidy and development in floodplains
  - —as substitute for disaster assistance
  - —choice of participation by individuals
  - —retargeting of premiums to local communities
  - —gap between adoption and implementation
  - —lessons for other hazards
- effects of relocation on business
- acceptability y of flood losses by the public
- examination of the land acquisition question
- macroeconomic evaluation of impact of floodplain management
- models for State government programs
- evaluation of agency compliance with flood management objective
- opportunities in architectural design related to floods

SOURCE Office of Technology Assessment.

Land Use Management

Land use management is the most effective tool for mitigating flood hazards in the long term. Its costs, however, are incurred in the short term and its benefits are deferred and difficult to evaluate. Therefore, it is politically the most difficult measure to implement.

Land use control could largely be used to remove land from residential and commercial use via acquisition by Federal, State, or local governments. Particular attention should be given, in flood hazards areas, to long-term land acquisition programs over a period of 30 to 40 years, the usual turnover time for structures. Land management can in this way be closely tied to other social goals such as in urban and rural development, and cause a minimum of dislocation in long-term land tenure.

A Federal Opportunity: Leadership by Example

The large number of buildings and structures owned or subsidized by Federal, State, or local governments that are located in flood hazards areas offer an opportunity for leadership. The locations of federally subsidized structures, as well as Federal buildings, is an opportunity for Federal leadership and at the same time could help to develop a more detailed sense of the macroeconomics and the social impacts of land use hazards management.

A move in the direction of leadership assumption by the Federal Government was made by Executive Order 11988, May 24, 1977, which in section 1 states:

> Each agency shall provide leadership and shall take action to reduce the risk of flood loss, to

minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrving out its responsibilities for (1) acquiring, managing, and disposing of Federal lands and facilities; (2) providing Federally undertaken, financed, or assisted construction and improvements; and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing.

The National Flood Insurance Program as Hazards Manager

At present NFIP is a subsidized program that operates locally to monitor the regulatory process. Its function could be expanded to make it the chief instrument by which flood hazards would be managed. This could be carried out by utilizing insurance premiums as a financial base for local flood management programs.

An All-Hazards Approach to Insurance

An argument has been made for an all-hazards strategy for dealing with the multiple problems caused by natural events confronting man and his works. A comprehensive catastrophe insurance program has been proposed that would consist of 13 parts.

- standardized all-risk coverage for all catastrophe perils except war,
- broad territorial divisions,
- Federal subsidies,
- coverage for residential and small business properties,
- land use control and loss prevention requirements,
- incentives for participation,
- elimination of Federal disaster assistance benefits for private property,
- full availability of insurance,
- Federal reinsurance,
- establishment of catastrophe reserves,
- adequate limits,
- mandatory deductibles, and
- administration by a combination of the private and public sectors.

The Mission of the Corps of Engineers

The historical role of the Corps of Engineers has been to build and maintain civil works for flood control. Although these have been beneficial, the present problem is how to effectively integrate them with strategies such as floodplain management. An examination of the successes and shortcomings of the Corps' civil works programs could provide insights for recommendations to modify its operations, particularly with respect to flood hazards control.

Research for Policy Planning

The policy planning of Federal agencies currently dealing with flood hazards would benefit from information generated by policy research.

Mapping Delays and Alternate Entry Policies

Mapping is a legislatively mandated prerequisite for joining the regular NFIP. Accomplishing the mapping is excessively time-consuming as well as extremely costly. This raises the question of whether there might not be some alternative procedure for entering the program more readily.

A number of suggestions have been made for simplifying the mapping requirement.

- The Flood Hazard Boundary Maps produced by NFIP are already in the hands of local communities. If amended to eliminate gross errors, these could be used locally until better information arrives.
- A method long in use at the State level is the use of fixed setbacks from the stream center or bank in the case of small streams and creeks.
- Refer to the area inundated by the flood of record (largest flood to have occurred in an area), or other significant historical flood, as the regulatory floodplain.
- Use the generalized relations between regulatory flood depth and readily measurable stream and/or drainage basin characteristics. Such an approach, using drainage area, stream width, and stream slope (measured from topographic maps) as independent variables, was proposed in 1961 in Pennsylvania.
- Use normalized curves to estimate flood discharges and stages which have reasonable correlation with regulatory flood stages estimated by traditional methods.
- The mapping of soils has also been shown to be a useful tool in identifying flood-prone areas in some regions.

H. Introduction

This report is a preliminary examination of the issues and options in flood hazards management and flood insurance. Its goals are to identify the needs of Congress for new or improved policy-related information, and to suggest specific information and knowledge that may be lacking which could be supplied by congressional support agencies, executive branch agencies, State and local governments, and private groups.

This report concerns:

- Trends with respect to the physical, social, institutional, and other elements of society that relate to flood hazards.
- Policy issues (i.e., areas of enduring public conflict) associated with reducing flood hazards.
- The Iifecycle of a flood hazard, from man-'s -- first movement into a hazardous area through a flood disaster and subsequent recovery. The lifecycle concept is a useful new framework for relating trends, issues, responsibilities, and policy options.

From these three considerations, the report moves on to identify what additional knowledge is needed to improve the policy and operational aspects of flood hazards management. It concludes by presenting some policy options for further consideration by Congress.

III. Floods: A National Policy Concern

There are seven reasons for the growing concern about the management of flood hazards. These are:

- Repeated disasters from Hurricanes Camille (1969) and Agnes (1972) to recent dam failures and flash flooding have created and reinforced a national awareness of floods, and generated strong State and local political pressure for action. State and local interests are becoming more aware that the predominant measures of the past, physical flood control and disaster relief, are inadequate.
- Federal actions are directly or indirectly creating new legislation and regulation related to flood hazards management. A large number of programs, integrated in principle but not in practice, make up the complex of programs and policies for improving the management of natural resources, for the preservation of wetlands, and for wildlife conservation. Some programs, such as the Coastal Zone Management Act and the National Flood Insurance Program, have planning arrangements for both urban and rural areas.
- Structural or physical measures—in the form of levees, dikes, and dams—are increasingly seen as inadequate by themselves for a sound approach to flood hazards management that would both reduce risks and modify their impacts. Nonstructural measures, such as land use planning, are now becoming important complements to the physical approaches.
- Huge new catastrophes with extensive loss of life and property have become more likely as the population-at-risk increases.
- The political implications of adopting alternative strategies to the physical control of floods could be significant. A reduction in physical flood control measures implies a decrease in the direct economic benefits from construction and employment. Furthermore, adopting nonstructural measures to mitigate flood hazards implies new land use controls. These are widely perceived as being disadvantageous in the short term to some important local interests.
- Political boundaries are not respected by floods. Consequently, their effects and their management overflow the jurisdictions of States, counties, and local governments. This gives flood events a regional character and thus poses problems of intergovernmental coordination in the management of floodplains.
- New knowledge about the causes and effects of floods stimulates an interest in putting that new knowledge into effective practice.

THE PHYSICAL BASES OF FLOODS

The three principal causes of floods in the United States are the overflow of riverbanks, flash floods, and hurricane-induced surges of water. Numerous other phenomena can also *cause* significant flood problems. For example, seiches, which are surges of water that principally occur in lakes and large water bodies as a consequence of sharp changes in atmospheric pressure, do substantial damage in the Great Lakes region. In addition to Hawaii and Alaska, extensive coastal areas in the United States are subject to tsunamis, formerly called tidal waves.

Civil works, notably dams, may break, creating their own artificially induced floods. Flooding may also occur as a result of natural or artificially induced soil subsidence. Another manmade factor in flooding is back flushing through water conduits, especially in sewer systems.

Flood hazards may also originate from causes quite remote from the flood site itself. Land clearance of forests for farming may change the local ecology, thereby altering runoff water retention characteristics in a river basin. Depending on the size of the basin and the extent of the changes made, this may become a primary source of flooding.

A large part of the national shoreline is vulnerable to continuing erosion from flood-related events. Average annual losses exceed $300 million.1 With the population continuing to move

IGilbert F. White, and Eugene J. Haas, *Assessment of Research* on Natural Hazards (Cambridge, Mass.: The M.I.T. Press, 1975), p. 361.

toward coastal areas in greater numbers as trends indicate, coastal erosion will be responsible for a greater percentage of flood losses. (This particular hazard has its own set of problems, which are discussed in appendix A.)

When large areas of cities and suburbs are covered with concrete, asphalt, and buildings, a drainage problem is created because the soil's natural ability to retain water is sharply reduced. This can seriously aggravate flooding problems. A classic example is the so-called Four Mile Run in the northern Virginia area of suburban Washington, D.C. In part, as a result of extensive development, Four Mile Run experienced two officially designated flood disasters in 1970.[2]

Occasionally, a geophysical event is indirectly responsible for a flood disaster. For example, a 1andslide caused by heavy rains may, if it falls into an artificial lake, cause a wave to overflow the dam, and an earthquake may induce a landslide or cause a dam to fail. (Dam failures will not be given further consideration in this report since they are a subject of current investigation and appear to be receiving adequate attention.)

The principal sources of floods roughly in order of attributable losses are:[3]

- riverbank overflow,
- conduit backwater flood,
- groundwater flood,
- headwater flood,
- flash flood,
- subsidence flood,
- ice backup,
- debris backup,
- dam breakage, and
- geological sink flood.

THE GEOGRAPHIC SCOPE OF FLOODS

Flooding is primarily a problem in river valleys, on floodplains, in the coastal zone, and on the perimeters of large lakes. Unfortunately, historical necessity and esthetic appeal make areas prone to flood hazards among the most attractive in which to live or work.

[2]Wesley Marx, Acts of God Acts of *Man (New* York: Coward McCann and Geoghegan, 1977), p. 46.

[3]D. Earl Jones, Chief, Field Services Branch, Office of Technical Support, Department of Housing and Urban Development, personal communication, 1978.

The principal river basins and coastal zones that are subject to floods are shown in figure 2. Both rural and urban communities are vulnerable. Figure 3 represents a principal river basin in New York State. The historical pattern and frequency of flooding in that area are shown in table 2. This particular river basin illustrates a common pattern in the temporal distribution of floods, namely their relative infrequency. Between 1886 and 1972 there were 12 major floods due to heavy rain, snowmelt, hurricanes, or other causes. While their rare occurrence may remove floods as a source of constant concern to both residents and local governments, it necessitates bringing foresight in long-range planning to flood management.

THE COSTS OF FLOODS

It is difficult to calculate accurately the costs of flood hazards or of the measures taken to alleviate or moderate them. However, useful calculations can be made of the cost of prudent means for preventing or mitigating possible flood losses. Calculation can also give a sense of the magnitude of damage that floods have caused, and can be used to create an awareness of the role that current choices play in determining future losses. In the following sections patterns of loss of life and property, and of the geographic distribution of the costs of floods are reviewed.

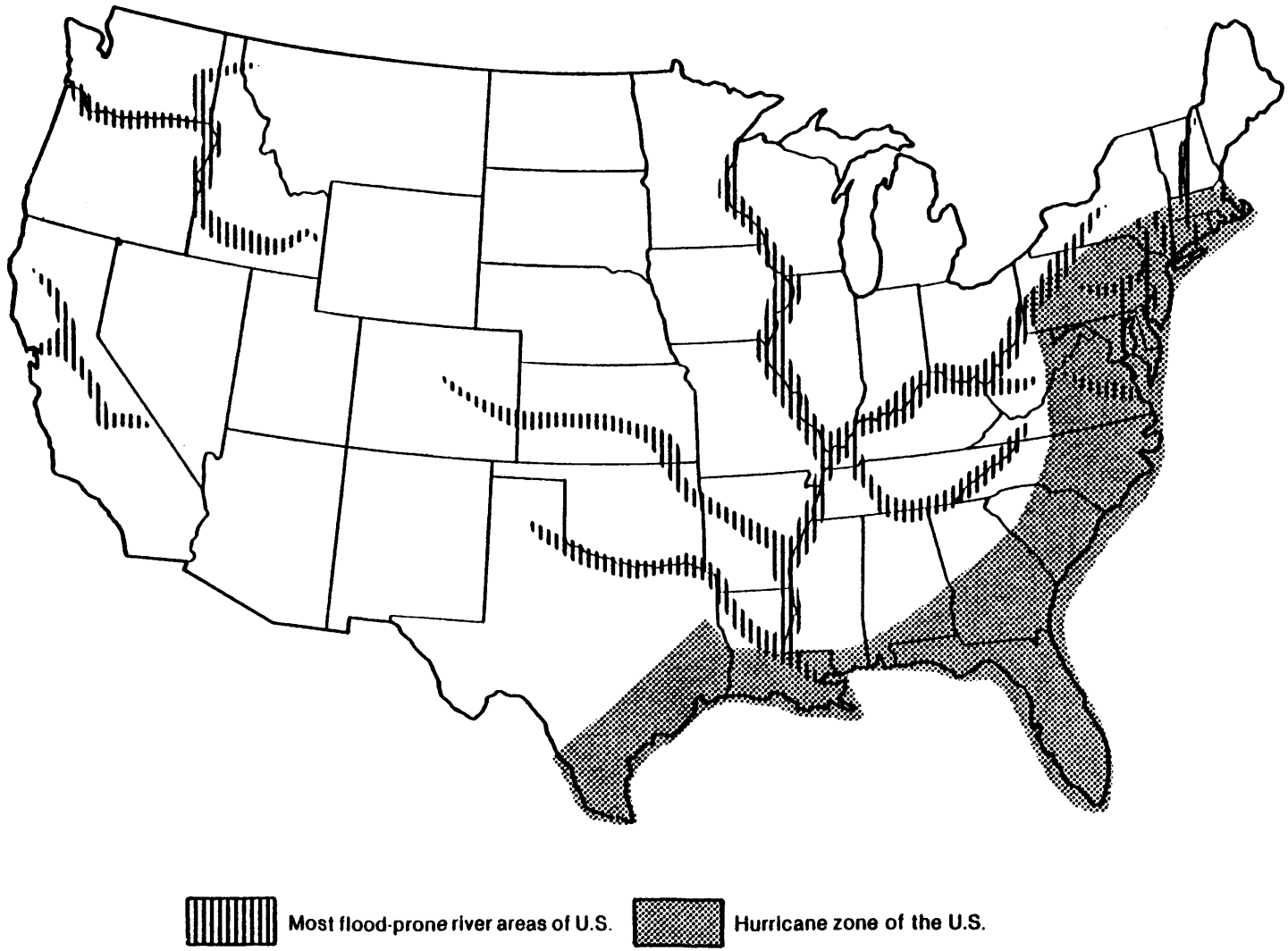
National Exposure to Flood Hazards

Seven percent of the 48 contiguous States are in the 100-year flood zone. This means that these areas are subject to a flood of such severity that there is a l-percent probability of its occurring in any given year. Goddard cites, in addition, potential catastrophes existing in other areas of the United States:[4]

- Over 200,000 square miles are subject to inundation, an area equal to the combined size of California and Ohio.
- One-sixth of all urban areas are in the 100-year floodplain.
- There are more than 20,000 flood-prone communities in the United States, and 16,500 square miles of urban floodplain.
- There are more than 6.4 million single-family houses located in floodplains.

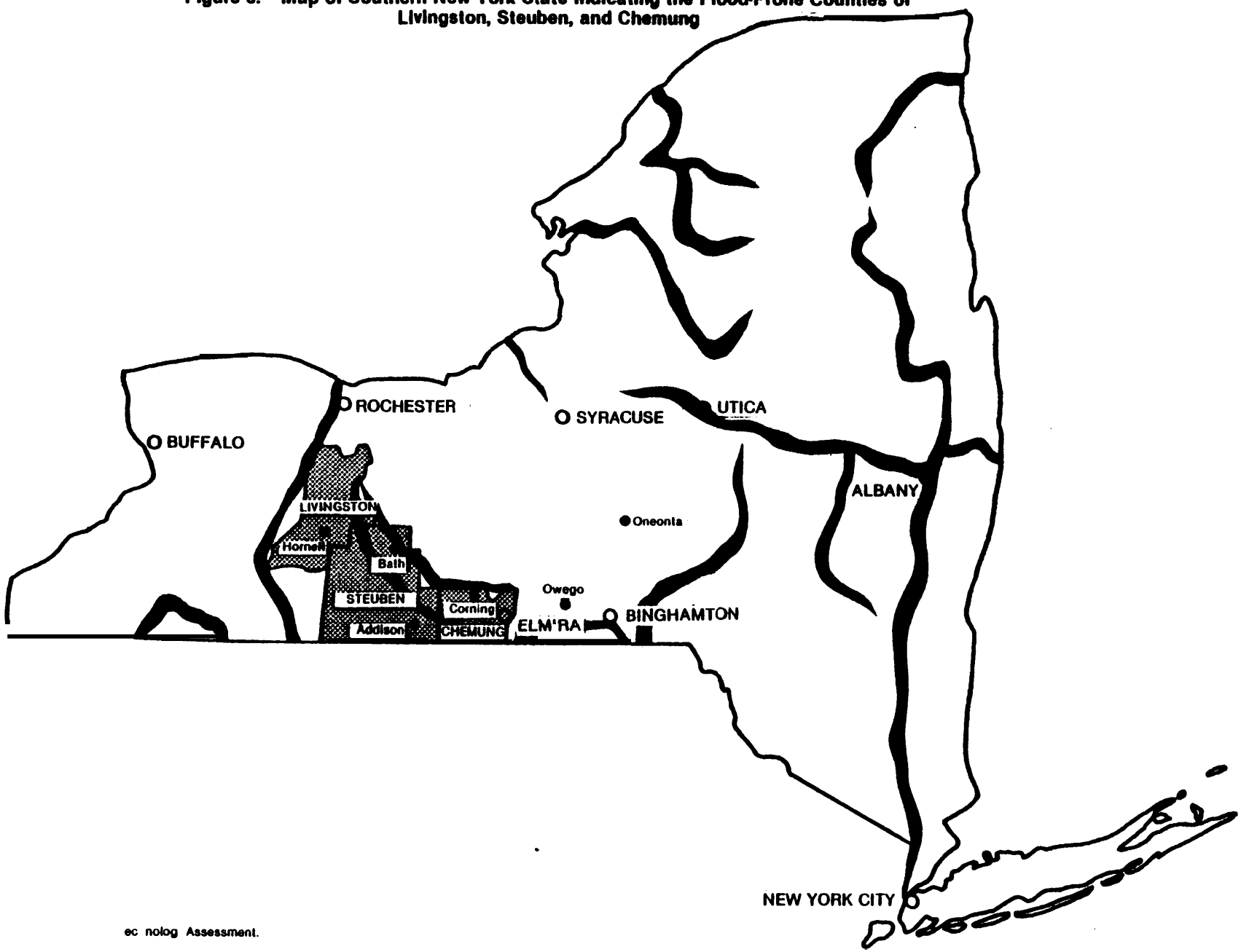
[4]J. E. Goddard, "The Nation's Increasing Vulnerability to Flood Catastrophe," *Journal of Soil and Conservation*, March-April 1976, pp. 48-52.

Figure 2.—Most Flood-Prone Areas of the United States



SO R General Adjustment B "Nature's Destructive Forces," 1972.

Figure 3.—Map of Southern New York State Indicating the Flood-Prone Counties of Livingston, Steuben, and Chemung



ec nolog Assessment.

Table 2.-Frequency and Cause of Flooding Between 1886 and 1972 in the New York State Counties of Livingston, Steuben, and Chemung

Jan. 5-12, 1886
Elmira (snowmelt, heavy rain, ice)
June 1-2, 1889
Elmira (cause not stated)
Sept. 9-10,1890
South Canisteo, Schuyler, Chemung, Steuben Counties generally (heavy rain)
May 20-21, 1894
Elmira (heavy rainfall)
Aug. 8, 1917
Binghamton, Elmira (heavy rain)
NOV. 30,1927
Hornell, Addison, Corning (heavy rains)
July 1935
Elmira (heavy rains)
May 25-28,1946
Corning, Elmira (heavy rains)
Dec. 10-11,1952
Elmira, Oneonta (heavy rains, snowmelt)
Oct. 15,1954
Binghamton, Elmira, Hornell (hurricane rains)
Mar. 30-31, 1960
Elmira–small stream flooding (heavy rains, snowmelt)
June 20-25, 1972
Bath, Corning, Elmira, Owego (heavy rains)

SOURCE: N.Y.S. Climatologist's Records, U.S. National Weather Service, Cornell University, Ithaca, N.Y.

From: David W. Tregaskis, "Needed Changes in the National Flood Insurance Act to Reflect Farm Flood Loss Experience," Department of Agricultural Economics, Cornell University, April 1975, app. 2.

Commerce, transportation, safety, and the necessity for water for industrial processes or domestic use *are* all valid reasons for people to live and work in floodplains. Several of these historical reasons, however, have been largely superseded by national roads and pipeline systems. Furthermore, living near water is both esthetically and environmentally appealing. This attracts large numbers of vacationers and homeowners. It thus creates a long-term conflict with those who wish to convert the floodplain into common use open space or other low-density purposes.

By 1973, over half the floodplains in urban areas had been developed. j This covered an area of town and country totaling approximately 8,800 square miles (see table 3), which is 125 times the size of the District of Columbia.

Despite over four decades of public investments for controlling floodwaters and providing safety for those living near hazard areas, the population and resources at risk are greater than ever. Hood losses are increasing, and the very construction that has made floodplains safer in the short run has increased both the number of people at risk and the degree of risk they will face in the long run.

[5]Ibid., p. 48.

Costs—Annual and Cumulative Losses

Loss of life, which depends on the size of a flood, as fluctuated over the past four decades (see figure 4). In this period, about 4,000 U.S. residents have lost their lives in floods. The exact number is uncertain. The Red Cross and the National Weather Service, working with unpublished data, indicate the average annual loss of life to be 47.6 and 57.2 respectively; and unpublished Federal Insurance Administration (FIA) data indicate that in 1975 there were 89 lives lost. This appears minor in comparison with the 1911 Yangtze River flood in which 100,000 persons died or the repeated flood disasters in Bangladesh. By comparison with death tolls in the less well-developed countries, the loss of life in the United States is relatively insignificant. The U.S. flood in which the most lives were lost—6,000—was caused by the Galveston, Tex., hurricane of 1900.

The historical pattern of losses in severe individual floods is illustrated in table 4. The average number of lives lost in 77 major floods from 1913 to 1973 was 52; 14 involved no known loss, and the 4 worst took 467, 313, 237, and 187 lives. Some sense of the annual loss of life in relation to national development can be seen from figure 4, which shows the annual loss of lives for each $10 million of property damage.

Property Losses

Property losses are rising rapidly. Between 1953 and 1973, the annual property loss, according to one estimate, has risen from $1.5 billion to $3.8 billion (1973 dollars), and Federal outlays for disaster relief for that same period rose from $52 million to $2.5 billion (1978 dollars).

In the four decades since 1936, approximately $14 billion has been expended on flood control construction including dikes, dams, levees, channels, and sea walls. But there appears to be no clear relationship between that construction and any reduction in loss of life or property.

Coastal erosion, while not totally attributable to flood hazard conditions, is closely associated

[6]Ibid., p. 49.
[7]Ibid., p. 49.
[8]Ibid., p. 50.

Table 3.-Exposure to Floods of Selected Urbanized Areas

Urbanized areab(UA)	Totala Population (1000s)	Totala Area (sq. mi.)	Floodplain (FP) Total Area (sq. mi.)	Total % of UAc	Developed Area (Sq. mi.)	Developed % of FPc
Asheville, N. C.	72.5	35.3d	1.6	4.4	1.0	65.0
Boise, Idaho	85.2	29.4	2.5	8.5	2.1	84.0
Boston, Mass.	2,652.6	664.4	62.4	9.4	11.9	19.1
Charleston,S.C.	228.4	99.2	39.8	40.1	21.2	53.3
Chicago, Ill.	6,714.6	1,227.2	131.8	10.3	75.1	57.0
Dallas,Tex.	1,338.7	674.2	146.1	21.7	28.0	19.2
Denver Colo.	1,047.3	292.8	30.6	10.5	19.1	62.2
Fargo, N. D.-Moorhead, Minn.	85.5	23.5	9.4	40.0	5.1	54.3
GreatFalls, Mont.	70.9	21.8	2.0	9.2	1.9	97.0
Harrisburg, Pa.	240.8	78.4	9.7	12.4	8.1	83.5
Lansing,Mich.	229.5	73.4	4.8	6.5	.9	18.8
Lincoln, Nebr.	153.4	52.1	13.8	26.5	6.9	49.6
Lorain-Elyria,Ohio	192.3	106.4	5.3	5.0	.6	11.3
Monroe, La.	90.6	40.1	32.5	81.0	26.8	82.4
Norfolk-Portsmouth, Va.	668.3	299.0	59.2	19.8	15.5	26.2
Omaha, Nebr.-Council Bluffs, Iowa	491.8	151.2	50.6	33.5	23.1	45.5
Phoenix, Ariz.	863.4	387.5	71.2	18.4	63.5	89.2
Portland,Oreg.	824.9	266.8	14.5	5.4	8.5	58.7
Reno, Nev.	99.7	37.5	2.0	5.3	.9	45.0
Richmond,Va.	416.6	144.6	12.9	8.9	1.7	13.2
St. Louis, Mo.Ill.	1,882.0	460.6	136.1	29.6	91.7	67.4
Salt LakeCity, Utah	479.4	184.3	12.9	7.0	10.1	78.3
SanJose,Calif.	1,025.3	277.2	80.0	28.8	67.9	84.7
Spokane,Wash.	229.6	77.8	1.9	2.4	.9	47.4
Tallahassee, Fla.	77.9	29.8	3.1	10.4	2.6	83.9
Texarkana,Tex.-Ark.	58.6	34.3e	4.7	13.8	2.1	44.2
Total	20,319.8	5,818.8	941.4	—	497.2	—
Average (weighted)				16.2		52.8

[a]Natural 100-year floodplain.
[b]Established and reported by U.S. Bureau of Census, 1970.
[c]Because areas are rounded to tenths, some percentages may not agree.
[d]Bureau of the Census limits, but revised measurements.
[e]Includes the additional incorporated areas.

SOURCE: American Society Civil Engineers UWRRP Technical Memorandum No. 19.

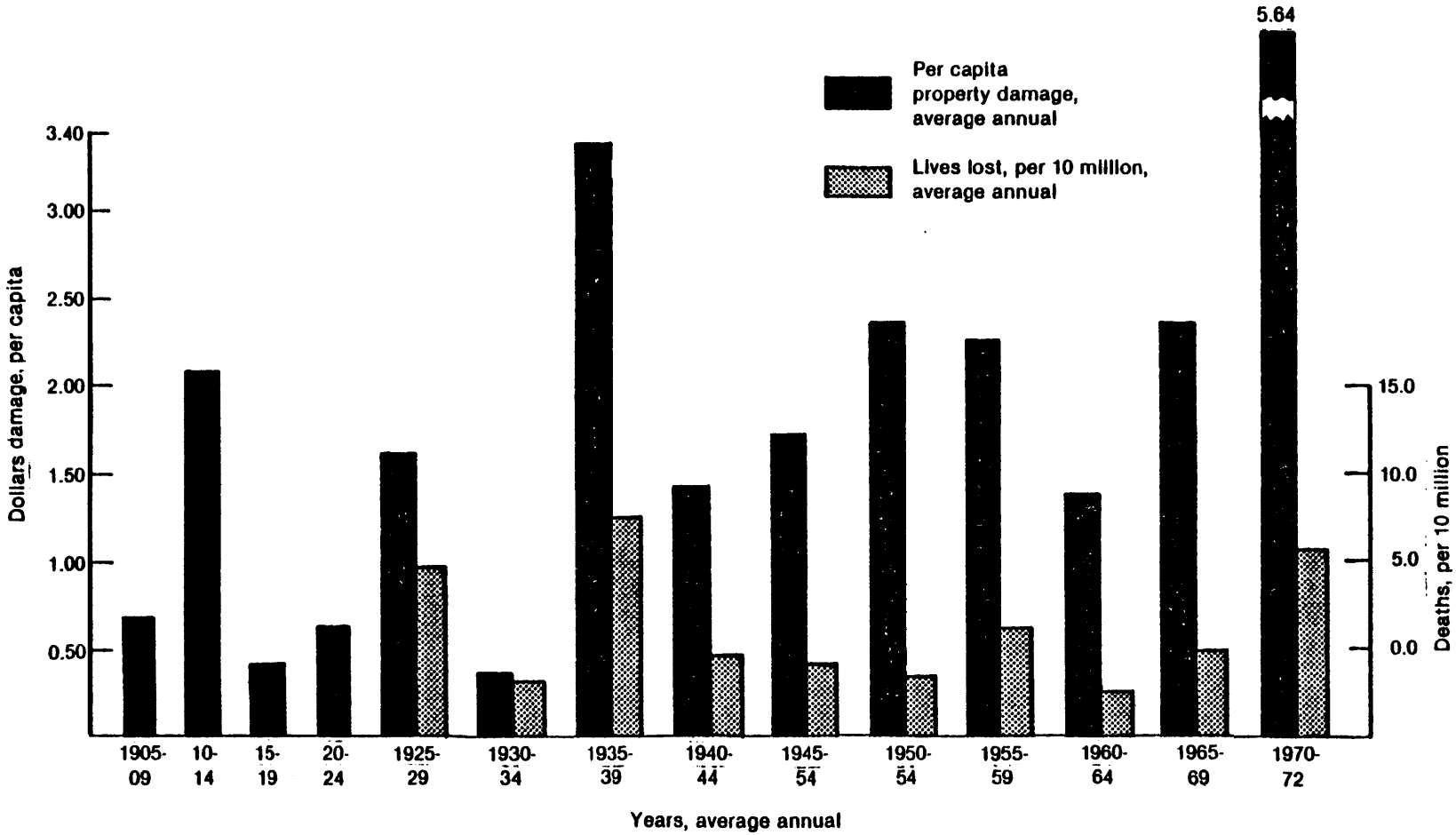
with severe weather, particularly hurricanes. (See appendix A for additional discussion.) From $300 million to $400 million in property losses occur annually in the coastal zones due to erosion.[9] The Corps of Engineers reported in 1971 that 15,400 miles of U.S. shoreline experienced significant erosion with some 2,700 miles considered to be in critical condition.[10] In Michigan alone, with 3,000 miles of shoreline, property losses over a 3½-year period were approximately $47,000 per mile.[11]

There is as much as a twofold or threefold variation in the estimates of flood losses. This is due in part to the lack of systematic accounting, and in part to the methods used in calculating the value of flood losses. Replacement value and depreciation value give quite different loss estimates. One comprehensive systematic evaluation by Earl Jones of the Department of Housing and Urban Development (table 5) puts total flood losses at $2.8 billion per year.

In an independent study, John Wiggins puts the annual losses due to floods at $1.9 billion, based solely on losses to structures.[12] At least one-third more could be added on if losses of infrastructure, telephones, utilities, water and sewage systems, pavement, etc., were counted. This would bring the total to about $2.6 billion per year. Regardless of the method of calculation, it is evident that the losses are large, and that the chief cause is riverbank overflow, with somewhat less caused by backwater and groundwater flooding.

[9]Gilbert F. White and Eugene J. Haas, op. cit., p. 361.
[10]U.S. Army Corps of Engineers, *National Shoreline Study*, August 1971, from the abstract.
[11]John W. Armstrong, Director, Coastal Zone Laboratory, University of Michigan, personal communication, 1978.
[12]John H. Wiggins, *Risk Reduction Through Natural Hazards Research*, for the National Science Foundation, Apr. 21, 1976, from the executive summary.

Figure 4.—Losses in United States Floods, 1905–72



SOURCE: Gilbert F. White and Eugene J. Haas, *Assessment of Research on Natural Hazards*, University of Colorado, 1975, p. 256. From White, et al. 1958; NOAA 1971; 1972.

Table 4.-Losses in Individual Severe Floods in the United States Since July 1902
(Property losses in thousands of dollars)

Date"	Location	Lives*.	ProDerty
May-June 1903	Kansas, lower Missouri, and upper Mississippi Rivers	100	$ 40,000
March 1912	Lower Mississippi River	—	70,000
March 1913	Ohio River and tributaries	467	147,000
December 1913	Texas Rivers	177	9,000
June 1921	Arkansas River in State of Colorado	120	25,000
September 1921	Texas Rivers	215	19,000
Spring of 1927	Mississippi Valley	313	284,118
November 1927	New England Rivers	88	45,578
May-June 1935	Republican and Kansas Rivers	110	18,000
July 1935	Upper Susquehanna tributaries	52	26,000
March-April 1936	Rivers in Eastern United States	107	270,000
January-February 1937	Ohio and lower Mississipi River basins	137	417,685
March 1938	Streams in southern California	79	24,500
September 1938	Rivers in New England	—	37,000
July 1939	Licking and Kentucky Rivers	78	1,715
August 1940	Rivers in southern Virginia, the Carolinas, and eastern Tennessee	40	12,000
May 1942	Delaware and Susquehanna River Basins	33	13,000
July 1942	Upper Allegheny River and Sinnamahoning Creek Basins	15	10,000
November-December 1942	Willamette River	10	6,900
April-June1943	Maumee, Wabash, upper Mississippi Missouri White,and Arkansas River Basins	60	172,500
August 1943	Little Kanawha River	23	1,300
April-June1944	Upper Mississippi Missouri, Arkansas, Red, and lower Mississippi River Basins and eastTexas rivers	17	82,000
February-March 1945	Ohio River	18	30,000
May-July 1947	Lower Missouri and middle Mississippi River Basins	29	235,000
May-June1948	Columbia River Basina	35	101,725
May 1949	Trinity River	10	14,000
June 1949	Shenandoah and Potomac Rivers	11	8,850
June1950	Rivers in central West Virginia	31	4,020
June-July 1951	Kansas and Missouri b	28	923,224
April 1952	Red River of the North, upper Mississippi and Missouri River Basins c	11	198,000
April-May1953	Louisiana andTexas	12	38,959
June 1953	Northwestern Iowa	14	32,950
June 1954	Middle Rio Grande and lower Pecos Rivers	16	19,079
October 1954	Pecos River in New Mexico	13	1,783
March 1955	Ohio River Basin	15	14,396
August 1955	Hurricane "Dianne" floods in the Northeast d	187	714,079
December 1955	West coast rivers e	61	154,532
January-February 1957	Streams in southeastern Kentucky, southwestern West Virginia, and adjacent areas inTennessee and Virginia f	14	58,000
February 1957	Snake River and tributaries	—	20,500
April-June 1957	Rivers in Texas, Arkansas, Kansas, Louisiana, Missouri, and Oklahoma	18	105,000
June-July 1957	Wabash River and tributaries	—	63,000
June 1958	White and Wabash Rivers	—	63,000
July 1958	Flash flood on east Nishnabotna River (Iowa)	19	5,850
January 1959	Ohio River Basin	—	81,921
July 1961	Flash flooding on small streams in Charleston, W. Va.	22	3,238
March 1963	Ohio River Basin	26	97,600
June 1964	Montana	31	54,279
December 1964	California and Oregon	40	415,832
March 1964	Ohio River Basin	13	81,602
March-May 1965	Upper Mississippi, Missouri, and Red River of the north river basins[g]	16	181,325
May 1965	Brazos River	—	30,802
June 1965	South Platte River Basin	16	415,076
June 1965	Sanderson, Tex., flash flood	26	2,715
June 1965	Arkansas River Basin	16	58,340
April-May 1966	Sabine and Trinity Basins, Texas	14	20,100
June 1967	Platte River Basin in Nebraska	—	35,275
September 1967	Hurricane "Beulah" floods in Texas	—	98,239
August 1967	Tanana and Chena Rivers in Alaska	—	98,550
May 1968	Rivers in northern New Jersey	—	166,690
January-February 1969	Floods in California	60	399,233
March-April 1969	Snowmelt floods in upper Midwest[h]	—	151,000
July 1969	Northern Ohio	30	87,915

Table 4.-Losses in Individual Severe Floods in the United States Since July 1902, cont.
(Property losses in thousands of dollars)

Date*	Location	Lives**	Property
August 1969	James River Basin in Virginia	153	116,000
January 1970	Sacramento River Basin	18	38,120
September 1970	Arizona	23	5,000
October 1970	Puerto Rico	50	62,000
August 1971	NewJersey("Doria" rainfall)	-	138,700
September 1971	Southeastern Pennsylvania	13	19,010
February 1972	Buffalo Creek,W. Va.	125	10,000
May 1972	South-central Texas flash floods	18	17,500
June 1972	Black Hills of South Dakota	237	164,947
June 1972	Eastern United States (Hurricane "Agnes"floods)	105	4,019,721
Spring 1973	Mississippi system	33	1,154,770
May 1973	Flash flooding in mountains of North Carolina and southwest Virginia	12	29,485
June 1973	Connecticut Basin in Vermont, Connecticut, and New Hampshire	11	64,000
June 1973	San Jacinto Basin and small adjacent basins in southeast Texas	10	62,500

*The 1966 to 1972 Annual Issues of Climatological Data, National Summary (as well as various earlier issues) contain this table which lists additional significant severe floods during the period of record.
**No entry indicates that fewer than 10 lives were lost.
[a]Monthly Weather Review, January 1949.
[b]Technical Paper No. 17.
[c]Technical Paper No. 23.
[d]Technical Paper No. 26.
[e]Climatological Data, National Summary, December 1955.
[f]Climatological Data, National Summary, January 1957.
[g]Technical paper No. WB-3.
[h]NOAA Technical Report No. 13.
[i]Climatological Data, National Summary, October 1970.
[j]Climatological Data, National Summary, June 1972; Geological Survey Professional Paper 924.

Table 5.—Annual Property Loss Attributable to Floods

Source	Loss($)
Riverbank overflow	$l biilion
Conduit backwater flood	800 miilion
Groundwater flood	400 million
Headwater flood	250 miliion
Flashflood	200 million
Subsidence flood	70 miilion
Ice backup	20 million
Debris backup	20 miilion
Dam breakage	I0 million
Geological sink flood	I million
Total	$2.771 trillion

SOURCE: D. Earl Jones, personal communication.

The situation has been continuing to worsen, particularly with respect to the demography of urban, riverine, and coastal zone development. According to Gilbert White, the present rate of urban expansion into floodplains is between 1.5 to 2.5 percent annually.[13] This means roughly a doubling of the risks per generation. Encroachment on floodplains even occurs in areas with zero growth or declining population.

[13]Gilbert F. White, *Flood Hazard in the United States: A Research Assessment*, Monograph #NSF-RA-E-75-006 (Boulder, Colo.: Institute of Behavioral Science, University of Colorado), p. xviii.

Impending Catastrophes

Catastrophic floods are highly likely in more than one part of the United States. Galveston, Tex., Key Biscayne, Fla., Boulder, Colo., and Orange County, Calif., are examples of the many areas that are likely to experience flood disasters with possible losses of thousands of lives and billions of dollars in property damage. The tendency to think in terms of annual or average losses, which then become the sole criteria for planning, diverts attention from potential catastrophes.

The combination of unrestrained urban sprawl, expansion into coastal zones, and continued reliance on the engineering approach to floodplain management almost certainly presages catastrophic floods in the next several decades. The relatively small loss of life caused by floods in recent years belies the number of American cities and counties vulnerable to exceptionally high flood losses. The following potential disasters suggest the urgent need to move to more prudent management of flood hazards.

- **Colorado.**—According to a scenario proposed by Gilbert White, the city of Boulder faces a hypothetical catastrophic flood that could take over a hundred lives and cause $80 million worth of property damage.[14]

[14]Ibid., pp. 111-117.

- Florida. -In south Florida, floods accompanying a hurricane, according to White, could cause many deaths due to the vulnerability of bridges, causeways, and drawbridges to storm surges. Citing the transitory nature of Florida residents, he contends that a large part of its population has never experienced a severe hurricane. That ignorance could hamper evacuation and warning response:

  > In sum, the total loss of life is high. A storm surge well in advance of the hurricane's center catches many still preparing to evacuate. Flooding of escape routes due co heavy rain exacerbates the severe traffic tie-ups which are normally expected with a large number of automobiles. (Rush hour traffic probably represents less than 25 percent of the traffic which could be expected with a warning to **evacuate,** and even this amount cannot be accommodated without major delays.) Warning and evacuation as they now are planned and proceed are inadequate responses to the posited threat.[15]

- California. –In 1 month in 1966, the Santa Ana River basin suffered two storms of such severity that each was likely to occur only once in 30 years. They caused $85 million in damage and qualified three counties for Federal disaster relief. The flood control system itself came close to failing. This compelled the Corps of Engineers to study what 'the post-disaster consequences would be if a storm of greater magnitude should occur. The study was referred to by the Corps as a "standard project flood." It is, however, a reasonable upper limit guideline for providing a high degree of flood protection to an urban area.

  According to its description by Wesley Marx:

  > The corps exposed Orange County to a standard project flood on paper. River levees would breach. The junk autos needed to bolster levees in this situation simply do not exist, not even in auto-crazed southern California. Knotts Berry Farm and Movieland Wax Museum would be in 3 feet of water. Sleepy hamlets turned civic insomniacs—Anaheim, Garden Grove, Westminster, and Fountain Valley–would be wading in floodwaters. The Disney Matterhorn and freeway overpasses would be high ground. Rockwell International, McDonnell Douglas, Aerojet-General, and other corporations aiming for the moon would need hip boots. A naval weapons station would also be awash. Downriver, the oil town turned civic idol (proud Huntington Beach) would be calling for rowboats and seaplanes. Water would stand 2 to 10 feet deep over 156 square miles of the Nation's Fastest Growing County. Some 300,000 homes would be damaged. Total damage to homes, businesses and industries, transportation, work loss, and other economic entities would be an estimated $3 billion under 1974 conditions of development (the corps). This projected damage toll would equal that racked up by tropical storm Agnes, which performed over a much larger geographic area.[16]

The above forecasts of disasters that would be accompanied by a high loss of life and extensive property damage reflect the consequences of conditions typical of many American regions. Public policies that are largely limited to physical controls create a false sense of security which encourages the intensive development of vulnerable terrain.

The potential catastrophes described above have had very real, tragic precedents in recent history. On June 9, 1972, Rapid City, S. Dak., experienced the most destructive flash flood in the Nation's history. It took 231 lives and did more than $100 million worth of property damage (see table 6). Although the history of flooding in that area is well-documented, major floods had not occurred for five decades, and development took place unhampered by concerns about a flood hazard. Thus, it exemplifies the type of catastrophic destruction that could be experienced by other more densely developed areas as a consequence of an unusual flood-producing event, if floodplains continue to be developed without regard for the possibility of severe floods.

The flood history of Rapid City (see table 6), which was available to all of its flood planners, illustrates the consistent pattern of flooding that should have alerted them to the potentiality of a catastrophe.

Public policy in flood hazards management needs to be concerned with two types of flood risk. The first is a noncatastrophic flood. In this type, there is a slow and steady rise in losses. The second is the potential catastrophe, with enormous loss of lives and property.

[15]Gilbert F. White and Eugene J. Haas, op. cit., pp. 35-36.

[16]Wesley Marx, op.cit., p. 113.

Table 6.-Flood History of Rapid City, S. Oak.

Date of flood	Damages ($)	Loss of life
1.1878	?	1
2. 1883	?	—
3.1885	25,000	—
4.1890	50,000?	—
5.1901	?	—
6. 1907	100,000+	4?
7.1909	?	—
8.1909	5,000	
9. 1910	?	
10.1910	?	—
11.1920	250,000+	
12.1926	7	
13. 1929	?	—
14.1936	?	
15.1942	?	
16.1949	?	—
17.1952	?	—
18.1962	?	
19.1972	100,000,000+	231

SOURCE: Gilbert F. White, Flood *Hazard in the United States:* A *Research Assessment* (Boulder Colo.: University of Colorado, 1975), p. 60.

ELEMENTS OF NATIONAL RESPONSE

Since the Lower Mississippi Flood of 1927, the Federal Government has been closely involved with the planning, design, funding, construction, and operation of flood control programs. Table-i -- describes the significant Federal responses since that year. From these it can be seen that specific disasters have provided strong incentives for new initiatives.

Between 1928 and 1968, the major emphasis was on the construction of massive engineering projects including flood control dams and reservoirs, widening and straightening channels, and local levees, dikes, and floodwalls. The intent in each case was to restrain floodwaters from affecting human activities and settlements. These meas-

Table 7.-Chronology of Major Floods and Public Response

Date	Major flood disasters	Significant events in national response
1927. .	Lower Mississippi— 1927	Mississippi Flood Control Act of 1928
	New England—1927	
1930. .		Tennessee Valley Authority Act of 1933
		Report of Water Resources Committee of National Resources Board– 1934
1935. .	Kansas River– 1935	Flood Control Act of 1936
	Upper Susquehanna—1935	Flood Control Act of 1938
	Eastern United States–1936	
	Ohio/Middle Mississippi— 1937	
	New England— 1938	
1940. .		Flood Control Act of 1944
1945. .		Publication of "Human Adjustment to Floods" by G. F. White—1945
1950. .	Kansas and Missouri Rivers—1951	President's Commission on Water Resources Policy— 1950
		Watershed Protection and Flood Prevention Act of 1954
1955. .	New England—1955	Publication of *Floods* by Hoyt and Langbein— 1955
		Flood Insurance Act— 1956
1960. .	Gulf Coast—1960	Floodplain Information Program, Corps of Engineers— 1961
	Southwest and Midwest—1961	
	Atlantic Coast—1962	
	Louisiana—1964	
1965. .	Upper Mississippi— 1965	Southeastern Hurrican Disaster Relief Act of 1963
	Upper Mississippi— 1969	Water Resources Planning Act of 1965
		HUD Study on Flood insurance—1966
		Report of Task Force on Federal Flood Control Policy— 1966
		Executive Order 11296-1966
		National Flood Insurance Act of 1968
1970. .	Rapid, S. Oak.— 1972	Flood Disaster Protection Act of 1973
	Hurricane Agnes— 1972	Water Resources Development Act of 1974
	Upper Mississippi— 1973	
1975. .	Mid-Atlantic—1975	Executive Orders 11988, 11990–1977
	Massachusetts Coast— 1978	
	Southern California– 1978	

SOURCE: Office of Technology Assessment.

ures have been accompanied, to a limited extent, by floodplain zoning to prevent downstream channel encroachment (a condition frequently required by the Corps of Engineers that appears to be more honored in the breach than in the observance.) Other measures that have been employed in rural areas since the 1930's include reforestation and soil conservation techniques. Whenever floods have occurred despite these measures, various forms of public and private disaster assistance have been supplied. The Federal share of this assistance has been rising sharply.

Since 1968, the emphasis in national flood policy has shifted towards an increasing reliance on nonstructural measures, such as flood insurance and land management, for averting severe flood losses and possibly redistributing their economic burden. The National Flood Insurance Act of 1968 (see chapter VII) established a program for insuring buildings and their contents against flood damage in both coastal and riverine hazard areas. The program requires the adoption by each community of local regulations that satisfy minimum national standards for floodplain management, as a prerequisite to the sale of insurance to property owners. Additional legislation during the 1970's has broadened the National Flood Insurance Program to require the purchase of insurance as a condition to the approval of federally related financing in hazard areas. Two Acts in 1974 authorized Federal cost-sharing for nonstructural measures (such as land acquisition), and required that efforts be made to mitigate disasters as a condition of Federal disaster assistance. These and other pertinent Federal laws are summarized below (see table 7):

- Federal Flood Control Act (33 USCA sees. 701a et seq.); **Flood Control Act of** 1936 (Public Law 74-738); Flood Control Act of 1938 (Public Law 75-761); and subsequent Rivers and Harbors Acts.

  These comprise the organic Federal law concerning the control of floods by means of structural projects: dams, channelization, local protection works, etc. Primary responsibility is assigned to the U.S. Army Corps of Engineers, with the Department of Agriculture assigned jurisdiction over small upstream watersheds with problems of erosion and runoff. The 1936 Act set forth the fundamental criterion that Federal funding is restricted to projects whose "benefits to whosoever they may accrue exceed their estimated costs."

- **Watershed Protection and Flood Prevention** Act **of 1954** (Public Law 83-566; 16 USCA, sees. 1001 et seq.).

  This Act established the "small watershed" flood management program of the U.S. Department of Agriculture Soil Conservation Service. The Service is authorized to undertake planning studies for watersheds of less than 250,000 acres and to implement flood control programs including land treatment, construction of flood detention reservoirs, and other measures.

Ž Water Resources Planning Act of 1965 (Public Law 89-80, 42 USCA 1962 et seq.).

This Act established the U.S. Water Resources Council as an independent Federal agency responsible for the review and analysis of water resource issues and for the supervision of studies by river basin commissions. It also provided for the establishment of Federal river basin commissions, six of which are now in existence (New England, Ohio, Great Lakes, upper Mississippi; Missouri, and Pacific-Northwest.) This Act also authorized grants to States for water resource planning and studies.

- National **Flood Insurance Act (42** USCA sees. 4001 et seq.).

  Tide XIII of the Housing and Urban Development Act of 1968 (Public Law 90-448)

  Housing and Urban Development Act of 1969 (Public Law 91-152)

  Flood Disaster Protection **Act of 1973** (Public Law 93-234)

  This Act established the National Flood Insurance Program as a vehicle for promoting prudent management of floodplains, and for allocating some of the costs of flood losses to occupants of flood hazard areas through the mechanism of insurance. (See chapter VII.)

- **Water Resources Development Act of 1974, sec.** 73 (Public Law 93-251)

  This section requires those Federal agencies responsible for floodplain management to consider nonstructural alternatives to measures authorized in the Federal Flood Control Act. Federal agencies are authorized to participate in the implementation of such nonstructural alternatives at a level of 80 percent of total project costs or more.

- Disaster Relief Act of 1974, Sec. 406 (Public Law 93-288).

  This section requires as a condition of any disaster loan or grant made under this Act

that the recipient shall agree that reconstruction thereby assisted shall conform to applicable building standards. States and local governments encompassing property eligible for disaster assistance shall evaluate the existence of natural hazards and shall adopt necessary measures to mitigate such hazards.

Following this overview of the historical and current basis for policy concerns, a framework for flood hazards management is considered in the next chapter.

IV. A Framework for Flood Hazards Management

Flood hazards like other natural hazards have their origins in nature. Flood disasters, however, are a consequence of the intrusion of man and his works into an environment that puts them both at risk. The successful application of public policies to the management of flood hazards calls for integrating a number of factors. The three most fundamental of these are: human behavior and the choices people make; natural events and their probabilities; and governmental responsibilities.

Four considerations that have been found useful in addressing an integrated approach to the management of flood hazards are:

- the lifecycle of a flood hazard,
- the time frame needed for planning policy,
- the tools available to Government, and
- an analytical strategy to assist decisionmaking that extends beyond cost-benefit analysis.

THE LIFECYCLE OF A FLOOD HAZARD

An effective management strategy for moderating a flood hazard or any other natural hazard must take into account the hazard's total lifecycle as it evolves from the natural condition in an environment into the risk conditions created by people's intrusion in that environment. The lifecycle shown in figure 5 presents an overall picture from which the relative strengths and weaknesses in current public policy can be identified.

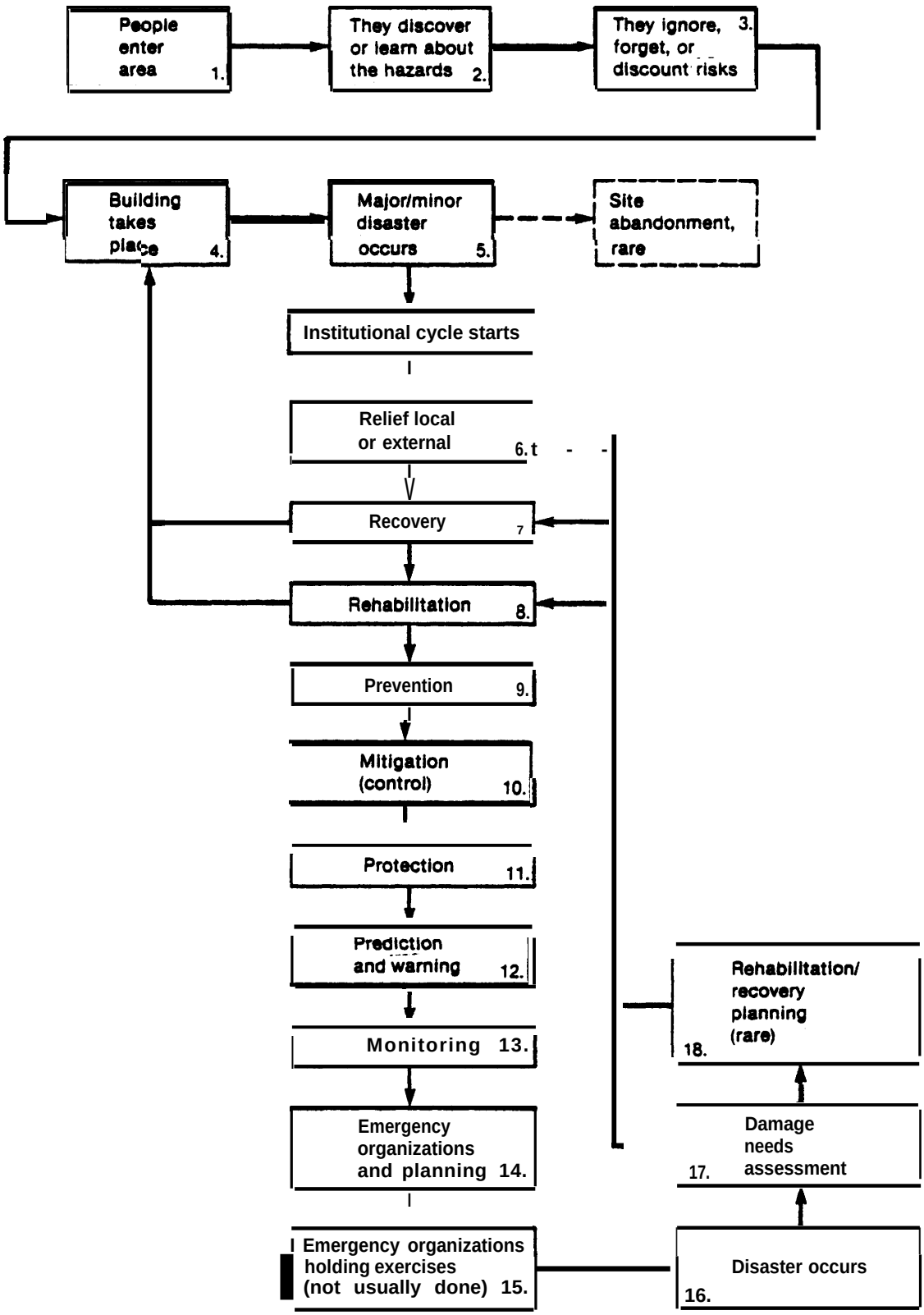
At present, the relatively strong capabilities of flood hazards management are its emergency organization and its planning for dealing with the immediate postdisaster situation (items 6 and 14 in figure 5). The readiness to exercise an emergency response (item 15) is a much weaker capability. Damage assessment (item 17) is relatively well-done after minor floods but much less so after major floods, in most areas. Prediction and warning capabilities (item 12) are being steadily improved, and measures taken for relief, recovery, and rehabilitation (items 6, 7, and 8) are adequate both for sudden disasters and for those that cause less than $1 billion in damage.

Planning for rehabilitation and recovery (item 18) is seriously deficient in all areas subject to floods. For maximum effectiveness, comprehensive plans to provide relief, as well as for rehabilitation, must be readied before a disaster strikes. The only long-term strategy that will reduce future losses from floods is to rebuild properly designed structures on suitable sites, avoiding the repetition of past errors. At the present time, however, without properly enforced planning for rehabilitation and recovery after a major flood, it is not likely that the unsound building patterns of the past will be changed.

Prevention has traditionally relied on controlling floods by means of civil engineering works. The increasing inadequacy of civil works that are not closely tied to land use planning is widely recognized. For this reason, how to make long-term land use planning an effective tool for controlling development in flood hazard areas and for guiding postdisaster recovery is a principal public policy question in flood hazards management.

The disorganized, almost haphazard, nature of the Government's efforts and capabilities for addressing a long-term integrated strategy is illustrated by figure 6. This figure shows that there are only a few Federal agencies with responsibility for more than one or two of the key elements in the lifecycle of a flood hazard, and that there isn't one single element which is the responsibility of a majority of the agencies. The President's recent Reorganization Plan for Emergency Preparedness and Response, which established the Federal Emergency Management Agency (FEMA), may help to more effectively organize these multiagencv responsibilities. (The issues confronting FEMA are discussed in a companion report mentioned in the preface.) The problem of integration is discussed in greater detail in chapter VI.

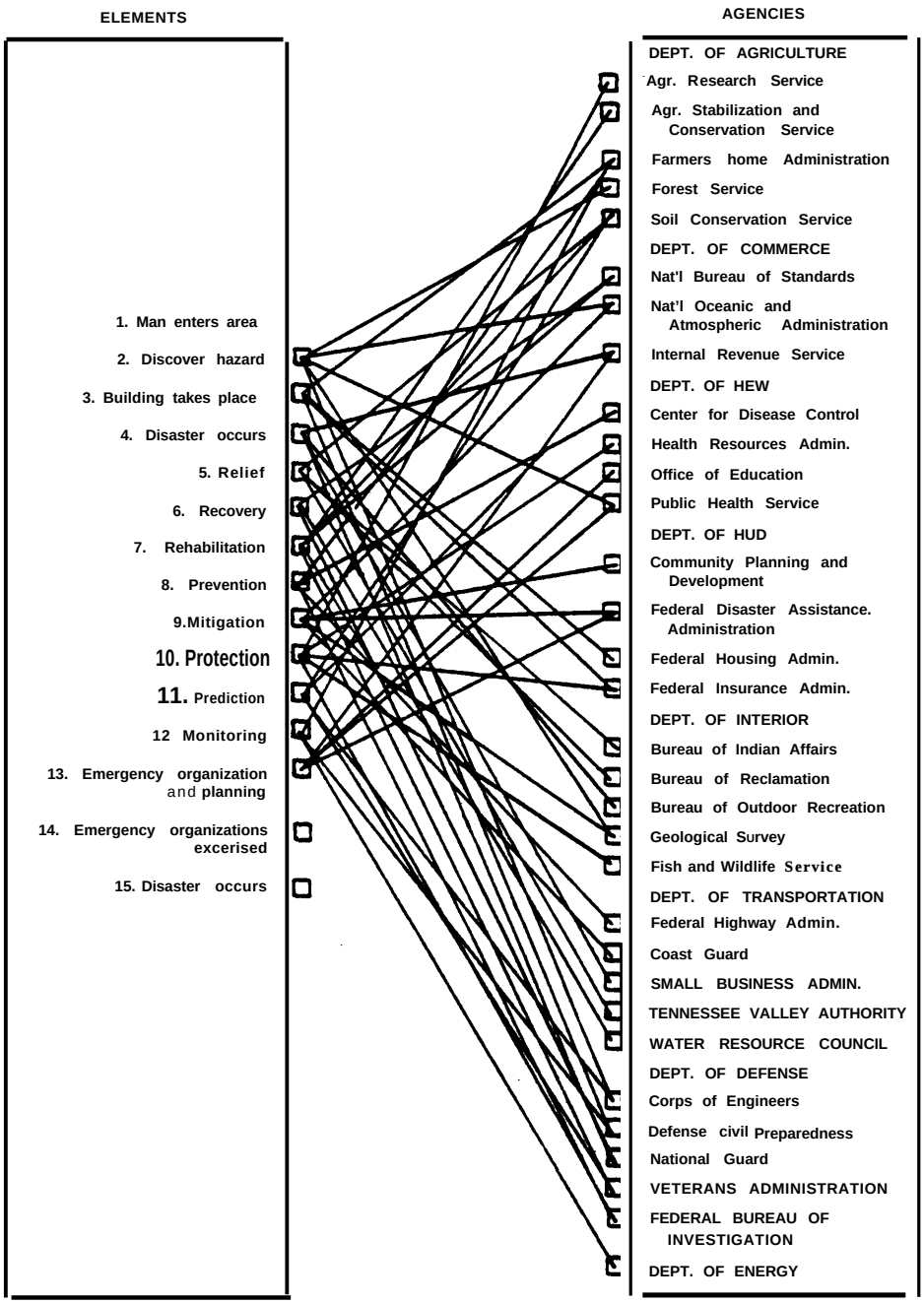
Figure 5.-Lifecycle of a Flood Hazard



SOURCE: Office of Technology Assessment.

Figure 6.-The Complexity and Confusion of Federal Responsibilities

Elements of the lifecycle as related to Federal actors



SOURCE: Compiled by OTA Staff.

WARNING

Whether for flash floods, for severe weather, for storm surges, or for tsunamis, flood warnings can substantially reduce the loss of life and property. Although the best estimates indicate that adequate warning would only reduce losses by about 10 percent, this represents a sizable saving with respect to the property base at risk. Thus, there appears to be a rising demand for warning services.

Flash floods affect over 15,000 communities and recreational areas. Since 1971, about 3,000 localities have been identified as having a high flash flood potential.1 All of these, along with another 3,000 areas with a somewhat less severe potential for such flooding, would benefit from a local flash flood warning program. To date, however, the National Weather Service only provides site-specific flash flood warning programs to 675 high potential areas.[2] This leaves over 5,300 areas in immediate need of such tailormade warning programs. The small number of new warning programs-75 to 100 annually–which are being put into effect by the National Weather Service, cannot meet the needs of these areas in a reasonable time.[3] Because of its limited staff of 150 hydrologists for the entire United States, the National Weather Service can only handle about 15 percent of the nationwide need for flash flood warnings.

There are approximately 9,000 remaining flood-prone localities where the problem is relatively less serious. These areas can be served by less site-specific, more generalized warnings, which are currently available or soon will be.[4]

Tsunamis, which are large ocean tides induced by earthquakes, have great destructive potential. In 1896, 27,000 Japanese were swept away by tsunamis, and in 1940, tsunamis wiped out every town along 800 km of the Chilean coast. The coastal areas of the contiguous 48 States have thus far been free of these devastating waves (although it is not certain whether earthquakes off the east coast are a significant hazard). Alaska and Hawaii, however, which are close to earthquake epicenters and therefore could be subject to sudden tsunamis, are most directly interested in the National Weather Service's tsunami-warning system. Recent technical developments in understanding these phenomena promise to improve the reliability and usefulness of their forecasting.

[1] Allen F. Flanders, National Weather Service, personal communication, Apr. 5, 1978.
[2] Ibid.
[3] Ibid.
[4] Ibid.

THE TIME FRAME OF PUBLIC POLICY PLANNING AND IMPLEMENTATION

Most of the lives and property at risk from floods are in cities or other heavily developed riverine floodplains and coastal zones. Considering that tens of millions of people and close to a trillion dollars of investments* are located in these flood hazard areas and that the average urban structure has a lifetime of about 40 years, it follows that if land use is changed too rapidly and too radically or there is too forceful an effort to make structural changes in property now at risk, excessive costs would be incurred.

To be effective, a national program for flood hazards management should take into account the 40-year average lifetime of urban structures. Then plans for removing and relocating structures at risk and hence people at risk, would be based on an implementation period of 30 to 40 years. A strategy that takes advantage of this average turnover time for urban structures would be the most acceptable from a socioeconomic point of view. It should not be implied, however, that such a strategy can be left to the normal operation of traditional market forces. Inadequately controlled market forces have been themselves a dominant factor in promoting flood hazard risks.

A major public policy objective framed over a turnover time of 30 to 40 years would not only

*One way to roughly estimate the value of structures at risk in a given flood zone is to multiply the per capita national investment in structures by the resident population. To include all public and private costs, that figure should be increased by roughly one-third co reflect the public service infrastructure (e.g., roads, sewers, bridges, etc.) at risk and increased even more to include the contents of homes and businesses.

Number of housing units	74 million
Average size	1,100 sq. ft.
Replacement cost/sq. ft.	$30
Population	220 million
Total residential investment	$ 11,350 per capita
Nonresidential sq. ft.	29 billion sq. ft.
Replacement cost/sq. ft.	$50
Population	220 million
Total nonresidential investment	$6, W@ per capita
Total national investment in structures	$17,940 per capita

SOURCE: Prepared by OTA with the assistance of John P. Eberhard.

minimize costs but would also make it possible to closely examine change as it takes place. This monitoring of change would provide Congress and the executive branch with feedback useful for ascertaining the progress of flood hazards management programs in meeting long-term national policy objectives.

TOOLS AVAILABLE FOR FLOOD HAZARDS MANAGEMENT

Numerous Governmental mechanisms are available for managing flood hazards. These can be conveniently organized in terms of three general strategies:

- Modifying the hazard by using structural control to alter the course or flow of the water.
- Moderating the impacts of flooding on individuals and communities through insurance, disaster relief, and tax adjustments.
- Reducing the risks of flood damage.

Modifying the Hazard

The traditional approach to flood hazards at the Federal, State, and local levels has primarily been to modify the course or flow of water by the application of physical methods. The volume of runoff during the peak stage of a flood; the time of occurrence and the duration; the extent of area flooded; and the velocity and depth of the water, thus the amount of pollutants and debris carried by the flood, can all be modified by physical means such as: dams, dikes, levees, flood walls, channel alterations, spillways, land treatment, and other civil works.

The adequacy of such physical methods as the predominant approach to controlling flood hazards is increasingly being questioned. Reliance solely on civil works, which cannot possibly be constructed to protect against every potential flood, encourages "apparently" protected flood zones to be developed. This, in turn, may lay the groundwork for larger, rather than smaller, future disasters. -----

Moderating the Impacts

Flood emergency measures, which range from emergency flood-proofing and disaster contingency preparedness to the warning of impending danger, are other traditional approaches to flood hazards. These measures by themselves, however, are recognized as inadequate for effectively dealing with the consequences of floods. Warning schemes, for example, may save a few lives but at most reduce property loss only by about 10 percent, as brought out in the flood workshop.

Once a flood occurs, postdisaster recovery measures such as insurance and tax adjustments are needed to moderate its impacts. A public policy dilemma associated with postrecovery measures is the extent to which they encourage risk-taking. If a community knows that should a disaster strike it will receive assistance and relief in the form of low-cost and subsidized insurance, this expectation could act to discourage the use of more effective preventive measures.

Reducing the Risks

The approach to the management of flood hazards is shifting towards measures that reduce the susceptibility to flood damage by integrating land management techniques, such as restricted occupancy, with traditional strategies and tools, such as civil works. The emphasis is increasingly being placed on such risk reduction measures as zoning codes, regulations, the implementation of development and redevelopment plans, and policies to improve the design and location of structures.

These measures are not equally suitable for every situation. Some, e.g., zoning restrictions, are more applicable to the development of untouched floodplains, others, e.g., flood-proofing, to urban rather than rural areas. The chief difficulty in implementing these approaches is that they reverse the traditional time sequence in which benefits are dispensed. Consequently, the political advantages to National, State, and local leaders would be considerably altered. Risk reduction measures also shift the burden of integrating and applying knowledge from the Federal Government to State and local levels. This places great demands on their skilled, but relatively small, professional staffs. A further complication is that State and local jurisdictions tend to be subject to pressure from narrow and short-term special interests. The principal policy tools for managing flood hazards are shown in table 8.

The limitations of the strategies for each of the three methods of flood hazards management: modifying the hazard, moderating the impacts, and reducing the risks are shown in table 9. Four

Table 8.-Governmental Strategies and Tools for Flood Hazards Management

Modify the hazard

Dams and reservoirs
Dikes, levees, floodwalls
Channel alterations
High-flow diversions and spillways
storm drainage
Land treatment measures
. reduction of erosion
. vegetation
• terraces
. runoff division
Onsite detection measures
Watershed treatment

Moderate the impacts

Flood insurance
Tax adjustments
• amortization for nonconforming uses
. reinforcement of regulatory policies
Forecasting and warning evaluation
Flood emergency measures
. emergency flood-proofing
• exercise of emergency response groups

Coordination of response and rescue

. communication links
. preflood planning
• damage assessment
Disaster assistance
. loans
. temporary housing, etc.
Ž direct compensation
Postdisaster recovery: rehabilitation coordination with other renewal objectives
Remote sensing

Reduce the risks

Regulations
• zoning
• subdivision regulations; standard setting
• building codes
. housing codes
• sanitary and well codes; health codes
• realtor disclosure of risk
• land acquisition

Development and redevelopment policies

• design and location of sensitive public services
• open space acquisition; public ownership
• easements
• redevelopment and renewal
• permanent evacuation
• tax incentives/disincentives subsidies, grants, loans
Preparedness and response planning
• training
• postaudits
• research; futures research
• coordination and support of planning
• impact analysis
Flood-proofing buildings and structures
• public awareness programs
• training local hazard personnel; training residents
Program and project evaluation
Priority setting and policy definition

SOURCE: Office of Technology Assessment.

Table 9.-Relevance of Nonstructural Measures to Floodplain Management Objectives

Nonstructural measure	Reduce existing losses	Prevent increased losses	Redis. tribute losses
Flood insurance	no	no	yes
Flood warning and emergency evacuation	yes	yes	no
Acquisition in fee	no	yes	no
Clearance/relocation	yes	no	no
Acquisition of rights less than fee	no	yes	no
Floodplain zoning	no	yes	no
Tidal wetland regulations	no	yes	no
Building codes	no	yes	no
Subdivision regulations	no	yes	no
Flood proofing	yes	yes	no
Control of utility location	no	yes	no
Encroachment regulations	no	yes	no
Emergency relief	no	no	yes
Education and information	yes	yes	no

SOURCE: Philip B. Cheney and H. Crane Miller. "The Application of Nonstructural Measures to Coastal Flooding," for *The New England River Basin's Commission,* June 1975, p. 12.

of the fourteen nonstructural measures listed would reduce existing losses, eleven would prevent increased losses, and two would redistribute losses. None would accomplish all three. It follows, therefore, that there is a need to integrate nonstructural with structural approaches.

Historically, the preferred measure has been to use civil engineering to modify the hazard by constructing dams, dikes, levees, etc., which reduce the risks for the typical more frequent but relatively minor floods. This approach, however, has several disadvantages. It is the only method that can actually increase the risk of life and property losses in many areas. This could happen if there were a major event that exceeded the planning specifications of the protective physical construction in a flood hazard area. Furthermore, by encouraging development in areas that are not holly protected against all possible events, the reliance on civil works can place additional lives and property at risk. There is no economically practical way to modify a flood hazard that can protect against a rare or catastrophic event.

The strategies that moderate the impacts of floods do so in three ways: 1) by spreading the loss, e.g.) through insurance; 2) by relieving the short-term stresses, e.g., through low-cost loans; and 3) by cutting the losses by some small percentage, e.g., through emergency flood-proofing or early warning.

Regulations, development and redevelopment policies, flood-proofin, buildings and structures,

education, and information are some of the strategies that can be used to reduce the risk of floods. It is socially desirable to redistribute flood losses through such means as insurance and relief. By themselves, risk-reducing strategies tend to incur excessive opportunity costs, since to reach a high level of risk reduction could be so costly as to drain public resources away from other meritorious public projects. These strategies also fail to deal effectively with the short-run and transitional problems of existing communities that are at risk during the changeover period from one set of strategies to another.

Ten approaches or policy options available to Government for implementing nonstructural measures are displayed in table 10. The desired outcomes are qualified by the limitations of such means. On the basis of surveys of the willingness of individuals to employ particular loss reduction or hazards management strategies, conducted by L. Douglas James of the Georgia Institute of Technology, he arrived at eight "individual factors affecting response to implementation means."[5] These are:

- time and inclination to execute individual measures,
- faith in availablilty to act,
- seclusion versus access as a reason for floodplain occupancy,
- sympathy for program goals and objectives,
- willingness to conform to regulation,
- philosophy of individual on public versus private responsibility,
- perceived personal benefits, and
- perceived personal losses.

The individual response data coupled with the policy options listed in table 10 suggest three determinants of successful policies for floodplain management:

- the establishment of a coherent Federal policy,

*Opportunity costs are the benefits forgone in making one choice over another. Every economic decision involves opportunity costs.

[5]L. Douglas James, "Formulation of Nonstructural Flood Control Programs," Water Resources *Bulletin*, August 1975, p. *693.*

Table 10.-Means or Policy Options in the Implementation of Nonstructural Measures

Means or policy options	Desired response	Limitations
1) Disseminate information warning of an impending flood emergency	Immediate employment of short-term measures and a later inducement to consider individual long-term measures	Some don't receive the warning, some don't take it seriously, some don't know what to do, some unable to respond
2) Disseminate information detailing hazards on the floodplain	Induce greater use of individual long-term measures	Same as above, plus some pursue personal, not public, goals
3) Disseminate information on ecological effects of floodplain occupancy	Induce personal long-term measures by appealing to community welfare rather than personal hazard	Same as 2 -
4) Penalize, tax, or charge those failing to employ specified measures	Add a financial incentive to induce still greater use of individual measures	Difficult to set fair rates, burden on low-income groups
5) Provide trained experts to analyze and advise property managers	Add expertise to induce greater/ efficient use of individual measures	Poor communication, cost, different values
6) Deny group measures or financial relief to areas not requiring individual measures	Induce communities to require individual nonstructural measures; social pressure on mavericks	Communities object of intervention leading to nonenforcement
7) Legislate and enforce statutes requiring individual measures	complete compliance with statutes	Puts financial burden for a public policy on a few owners
8) Financially aid those who implement individual measure —insurance, subsidies	Add financial means to respond to expert advice	Puts financial burden on public, subsidizes floodplain occupants
9) Purchase hazard areas and leave in natural use	Ensure no development, improve recreation and natural areas	Expensive to buy and maintain
10) Purchase hazard area for redevelopment in optimum use	Ensure optimum development and compliance	Planners unable to figure precise optimums, puts Government in competition with private sector

SOURCE: L. Douglas James, "Formulation of Nonstructural Flood Control Programs," Water *Resources Bulletin*, August 1975, p. 690.

- the cooperation of community leaders and institutions in adopting and enforcing standards, and
- the predictability of individual response to specific policies.

As a rule, it should be recognized that in managing social problems and establishing a coherent Federal policy, institutions rarely have effective control over all or most of the fundamental variables affecting or likely to affect their interests. Thus, the institutions most directly responsible for the management of flood hazards have the least control over those variables that affect flood hazards in the long term. For example, money-lenders, the mortgage industry, banks, and Federal agencies such as the Federal Home Loan Bank Board are the predominant institutions that influence and control building construction and land use management. Often, the organizations that have the capability and power to reduce the potential of flood risk are inattentive or insensitive to this opportunity.

The limitations of the traditional approach to analyzing natural hazards have been examined in this chapter and three elements have been suggested as crucial to effective flood hazards management: 1) the lifecycle of a flood hazard, 2) the 30- to 40-year time frame of planning, and 3) the need to systematically integrate the three major methods of dealing with flood hazards; modifying the hazard, moderating the impacts, and reducing the risks.

The formal calculation of costs and benefits is a well-established, if not a paramount, element in flood control planning. The following section highlights the practical limitations of this technique. A framework is presented for a larger range of considerations that could usefully enter into those aspects of policy planning concerned with selecting and organizing the techniques and strategies for dealing with flood hazards.

BEYOND CALCULATING COSTS AND BENEFITS

The Flood Control Act of 1936 established the basic national flood management policy that prevailed for the next three decades. This policy emphasized reliance on massive flood control projects that would be built largely at Federal expense. (As a consequence of earlier "308 studies"* carried out by the Corps of Engineers, several hundred flood control projects were under consideration in 1936.

The Act specified that no project would be authorized by Congress unless its total benefits exceeded its total costs "to whomsoever they may accrue." This rule established a requirement for cost-benefit analysis in planning water resource projects. It was supplemented by the National Environment Policy Act of 1969 (Public Law 91-190), which requires that environmental impact statements be prepared for major Federal projects affecting the environment. An inherent shortcoming of applying cost-benefit analysis to water resource projects is that it has only served to justify individual projects, and even in these cases it has involved somewhat questionable assumptions about future costs and benefits. On the whole, cost-benefit analysis has been used to address basinwide or regional planning.

Alternative nonstructural measures have often been ignored as possible means of managing flood losses. For example, floodplain zoning to define land use could be used to limit the encroachment of development on downstream floodplains below a flood control dam. In the absence of a comprehensive analysis of the costs and benefits of alternative or complementary measures, flood losses have increased steadily since the 1936 Act as a consequence of the continued encroachment on downstream floodplains that are believed to be totally protected by flood control structures. If there is a flood that exceeds the capacity for which the protective structure was designed, great damage occurs.

During the 4 years, 1974-78, there were 127 floods, which the President declared were disasters, that exceeded the 100-year flood level.[6] There are, in fact, several thousand civil works that were designed to protect against the 100-year flood level. (This is the flood level that is used as the most common basis for designing protective civil works.) It would appear, therefore, from the above statistics that every year a number of these will be exceeded.

*"308 Studies" are provided for by the Rivers and Harbors Act of 1927, Public Law 560. These studies were among the earliest involving integrated planning.

[6]Richard Krimm, Federal Insurance Administration, OTA Workshop, Mar. 21, 1978.

Unfortunately, encroachments on downstream floodplains have frequently been anticipated and counted as benefits in the cost-benefit analysis for a given project. Initially, the benefits of flood control works were determined by the projected reduction of damage to existing buildings and associated activities in the floodplain. However, the method and tone of justification have been modified to include the reduction of property losses to future structures. Krutilla explains that "of 59 Corps of Engineers projects authorized by the 1965 Act that were 'justified' wholly or in part by flood control benefits, from 3 percent to 85 percent of the total flood control benefits were accounted for by expected future development in the floodplain. For half of all the projects, the proportion of benefits represented by anticipated future development in the floodplain amounted to over 40 percent. Approximately half of the single-purpose flood control projects would not have been 'justified', save for the anticipated more intensive use of the floodplain stimulated by the flood control projects "[7]

As civil works attract more people and property into flood hazard areas, the groundwork is laid for catastrophic floods because relatively unregulated growth is permitted. The situation is exacerbated by the possibility that poorly designed protective civil works may fail structurally. White elaborates:

> . . . Each stream reach protected by levees or dams is candidate for a flood exceeding the design capacity of the planned control works. The design rarely attempts to cope with a theoretically maximum possible event.[8]

The total cost of floods and flood hazards should include the losses directly associated with the floods themselves, and the construction and related infrastructure costs for flood control and flood hazards management. It is also useful to consider the costs that are not directly reflected in the Government outlays, such as changing land values and lost time and labor. The calculation of costs is complicated by the related matter of benefits. It turns out to be surprisingly difficult to ferret out and make sharp distinctions between costs and benefits.

As pointed out above, it is a frequent practice to include in the benefits the development of a floodplain that results from the security provided by flood control measures. But, viewing floodplain development as favorable puts new resources at risk that become potential costs when the flood control measures fail, as they ultimately must. The -- costs and benefits of natural hazards management should be treated in terms of a total lifecycle of development, from initial occupancy of the floodplain or coastal zone, through the flood disaster itself and the recovery period. Cost should also include the new risks generated by hazards management, operating costs, and private, personal, and business costs. A number of the factors that enter into a comprehensive cost-benefit calculation are shown in tables 11 and 12.

The complexity of a broad framework for flood hazards management cannot be overestimated. It is reflected in the following conditions that must be taken into consideration by any strategy for reducing flood damage.

- Impacts are marginal, not drastic or extreme.
- Impacts are chiefly economic or can be readily translated into economic or quasi-economic values.
- Impacts are chiefly direct.

However, even when cost-benefit analysis meets the above conditions, it may have, in practice, a number of serious limitations.

- It only provides a narrow range in which to search for possible impacts, and as normally practiced, does not actively search for all the impacts on society and the environment.
- It cannot deal satisfactorily with questions of equity involving the distribution of costs and benefits.
- It tends to distort or ignore impacts that cannot be directly measured in dollars.
- It tends to exclude externalities, indirect, and long-term effects.
- It does not alert decisionmakers to previously unsuspected risks or unidentified uncertainties.
- All of the above tend *to* become magnified when dealing with unprecedented technologies or projects ..?

[7] John V. Krutilla, "An Economic Approach to Coping With Flood Damage," Water Resources *Research*, **1966**, p. 185.

[8] Gilbert F. White, F/ *Hazard in the United States: A Research Assessment*, Monograph #NSF-RA-E-7 5-006 (Boulder, Colo.: Institute of Behavioral Science, University of Colorado), p. 32.

[9] V. T, Coates, *A Handbook of Technology Assessment* (The George Washington University, March 1979).

Table 11.-Identification of Costs by Sector

Category	Agricultural	Business	Organizational	Personal	Public
Direct . .	—Structural/building —Croplosses —Land and soil —Damage -Machinery/equip. -Cleanup –Other	–Inventory —Structural/building —Furnishings —Machinery/equip. —Avoidance —Cleanup –Other	-inventory -Structural/building —Furnishings -Machinery/equip. —Cleanup -Relief effort -Other	–Structural/building –Contents —Avoidance -Cleanup –Other	—Structural/buiiding —inventory —Furnishings -Machinery/equip. —Avoidance —Cleanup —Other
indirect.	-Lost productivity —Lost man-days —Land value	-Lost man-days —Lost business profit —Transportation problems —Property values	—Lost “man-days	—Transportation problems –Man day of effort to combat flood —Loss of wages —Property values	-Lost man-days —Redirection of effort to the flood —To estimate damage —Transportation problems —Opportunity cost/benefit of funds used to compensate victims —Cost of disruption of Government activity
Intan-gible . .		-Elasticity of new investment	—Loss of recreation enjoyment	-Exhaustion —Family separation –Loss of life —inconvenience	

SOURCE: Environment Canada, Technical Bulletin No. 81, P. 78, Halifax, Nova Scotia. 1974.

Table 12.-Identification of Benefits by Sector

category	Agricultural	Business	Organizational	Personal	Public
Direct . .	-Silt deposits	—Sale of damaged goods			
Indirect.	-Difference in price	-Flood recovery business prosper		—Relative decrease in property taxes	—Multipler effects of block infusions of Federal cash into the provincial economy —Multiplier effects of transferring public funds into private hands
Intan-gible . .	—Flood experience	— Flood experience	—Emergency training	—Flood experience –Unaffected got curiosity fulfilled —Unexpected public holiday —Other intangible benefits	—Emergency training —Sense of pride and accomplishment

SOURCE: Environment Canada. Technical Bulletin No. 81, P. 79, Halifax, Nova Scotia. 1974.

Further problems with cost-benefit analysis arise when faced with decisions and choices about:

- discount rates,
- the scope of benefits and costs entering into the analysis,
- the selection of alternative projects for comparison,
- double counting, and
- when an effect is a cost or a benefit.

Considering the limitations of cost-benefit analysis, a broader analytical framework appears to be required to develop the policy approaches and strategies needed to reduce flood damage. It is suggested here that the concept of technology assessment would provide such a framework.

Technology assessment (TA) is a type of policy study that attempts to provide decisionmakers with a base of information about the possible societal consequences of developing a new technology or of significant changes in an existing technology. It is an open-ended search, using various techniques both qualitative and quantitative,

for the potential impacts of a technological development on the economy, on the environment, on the polity, on social behavior, and on social institutions. TA examines what the need, the desirability, and the justification are for Government to intervene in order to stimulate or control the development of a new technology. It attempts to delineate the uncertainties involved in such an intervention as well as the societal costs and benefits; and it presents decisionmakers with a set of alternative or complementary policy options along with their long-range implications.

Recently, the application of TA throughout the Federal Government was reviewed. [10] There was little indication that TA under that or any other name was being used by the Corps of Engineers at the district or operating level as a policy tool for flood management. The Institute of Water Resources (IWR), however, does carry out a substantial amount of TA related studies.

IWR was created by Congress in 1969 to assist the Corps of Engineers in meeting new planning requirements arising from the public's concern over the environment and the quality of life. The principles and standards (P&S) published by the Water Resources Council in 1972, required planners to take into account regional development, economic development, environmental quality, and social well-being. In response, in 1975 the Corps promulgated a series of regulations (the 200 series) that provide guidelines to Corps planners for multiobjective planning. Many of the concepts of TA can be found in these regulations.

TA related activities are going on to some extent at the Waterways Experiment Station (Vicksburg, Miss.). The Station's report on water resources assessment methodology contains impact assessment and alternative evaluation intended to assist planners in meeting the social impact requirements of Corps regulations. The Construction Engineering Research Laboratory (Champaign-Urbana, Ill.) is also conducting research related to social impact assessment and the North Central Division of the Corps is in the initial phases of a study of the impacts of winter navigation in the Great Lakes.

In working towards a more comprehensive and effective decision-oriented planning process that uses TA concepts, the following 12 preliminary questions should be addressed before implementing any strategy to reduce flood damage. [11]

- What **systems** are affected by floods? (i.e., what entities are susceptible to flood damage? What are the kinds and causes of flood damage? What is the relative importance of the -- various kinds of damage? What priorities should these be given?)
- What are all the **alternative strategies** for preventing or significantly reducing the various kinds of flood damage?
- What **elements** of flood damage does each strategy significantly address? What degree of impact does it have?
- Is each particular strategy based on, or can it be supported by, **adequate data?**
- How does each strategy **compare** with others in its degree and scope of effectiveness, in its costs, and in its feasibility.
- What other strategies and measures must each be **linked to** in order to be maximally effective?
- Would the strategy work at **cross-purposes** to, or be neutralized by, any other measures to reduce flood damage? Might the strategy undermine another more effective strategy?
- Might the strategy have the effect of actually **increasing** certain kinds of potential flood damage?
- Is the strategy appropriate to or equally adaptable for **all types of flood-prone areas?**
- **Is** the implementation of the strategy **compatible with all the other requirements of the system** it affects? (For example, are specifications for elevated foundations compatible with the specifications for earthquake-proof foundations in areas—such as the west coast—where flood and earthquake zones overlap?
- What, if any, are the specific benefits of flooding? Of locating within a floodplain? How do these benefits compare with damage costs for each vulnerable area?
- Outside the issues of flood damage, what are the positive and negative **side-effects** that this strategy might have? What other policy areas intersect with flood policies? (e.g., a national land use policy, environmental impact policies, etc.)

[10] Program of Policy Studies in Science and Technology, *Technology* Assessment in *the Federal Agencies* (The George Washington University, March 1979).

[11] American Institute of Architects, An *Evaluative Approach to Alternative Strategies for Flood-Damage Intervention*, June 1974, p. 2.

Four elements useful in promoting an integrated approach to flood hazards management have been considered in this chapter.

- the concept of a flood hazard lifecycle,
- the time frame in which to plan flood-reducing policies,
- the array of tools available to Government for managing flood hazards, and
- technology assessment as an analytic strategy to expand the decisionmaking value of cost-benefit analysis.

In the next chapter, trends in flood hazards management as they relate to the concept of a flood hazard lifecycle will be discussed in order to elucidate current issues and future options.

V. Trends and Images of the Future

Trends analysis is central to understanding the future. It is useful in at least three ways. First, insofar as they are stable, trends define the boundaries on alternative future developments. Second, the examination of trends automatically forces one to search for underlying factors that may either stabilize or perturb the trend. Such shifts may come about gradually or they may be sudden. The third use of trends is to suggest opportunities for policy interventions to modify what would be a stable undesirable development, or to promote a desirable but otherwise unlikely change.

Understanding the long-term trends is one basis for formulating public policy since they suggest how the system is likely to evolve. Most public policy actions are unlikely to have major short-term consequences for the quality of life or the public well-being. Therefore, the trends discussed below cover an interval of 5 to 30 years. Two levels of trends in relation to flood hazards management are discussed:

- trends directly related to floods, and
- trends having to do with natural hazards in general. These include long-term trends in American society over the last several decades that form an overall societal context for most public policies including the management of natural hazards.

The trends identified below are often conflicting if not contradictory. This ambiguity and uncertainty about trends—their duration, significance, and origin—make assessing impacts difficult but fruitful.

Trends analysis cannot be limited only to those trends that lend themselves to quantitative, fully objective presentations. Some place must be made for informed subjective judgment. There is a trade-off in the sense that those circumstances most likely to be reflected in fully quantitative terms sometimes emerge as trends that are not on the leading edge of important change. Some attempt is made to accommodate judgment, opinion, and wisdom in the identification of important trends.

TRENDS DIRECTLY RELATED TO FLOODS

Trends that will shape the future of exposure to flood hazards in the United States fall into four categories:

- trends affecting the degree of risk posed by floods,
- the effects of demographic trends on flood hazards,
- evolving patterns of floodplain use, and
- trends in public policy responses.

Trends Related to Flood Risk

The most important risk-related trend is that public policies, by continuing to encourage floodplain development, are causing losses to continually rise and may cause catastrophes of unprecedented scale. The number of lives lost in these potential major events could easily exceed even the previous loss of 6,000 lives due to hurricane flooding in the summer of 1900 in Galveston, Tex.[1] The property losses would dwarf by comparison the sizable and increasing losses that are currently taking place.

Additional trends are:

- The increasing loss of life from floods. While low compared with that of developing countries, the loss of life has shown a slight upward trend over the past several decades.
- Property loss has grown. It is not clear how much the effect has been of true increases, inflation, better reporting schemes, insurance availability, or other factors. Nevertheless, there has been an accompanying trend to demand more Federal postdisaster assistance, with or without adequate preplanning and land use control.
- Public policy continues to promote the potential for life and property loss by permitting—if not actually encouraging—development on hazardous terrain. In some areas policy, or its

[1] James Cornell, *The Great International Disaster Book* (New York: Simon and Schuster, 1S'79), p. 112.

absence, causes more problems that it resolves. An example is that hotels, motels, highways, and housing are located along coastal shorelines, with little regard to potential hazardous conditions.

- "Acts of God" are a decreasingly important aspect of flood hazards. Advances in prediction and control techniques, in conjunction with proven measures to mitigate loss, improves the capability to reduce the number and severity of disasters.
- New and improved techniques for predicting phenomena, such as hurricanes and tornadoes, have created problems as well as benefits. The problems principally have to do with how to organize and manage an approach for dealing with the undesirable side effects of prediction.
- The technical ability to significantly modify weather, including specific phenomena such as hurricanes, is being continually improved. Society is only beginning to examine the ramifications of this capability.
- There are an increasing number of requests from communities for flood-warning services.

Trends in the Use of Flood Hazards Areas

The competition between land use and development interests for flood hazards areas has contributed to a variety of trends that are making development choices even more controversial. These include:

- A downtrend in the original historical reasons for the occupancy of floodplains. Business siting for cheap transportation, power, water-dependent processes, and housing close to the workplace no longer require proximity to bodies of water. The growth of the highway system, pipelines, railroads, and other transportation infrastructure has virtually eliminated the economic need to locate in floodplains.
- An increase in the population of floodplains, even in regions of zero or declining growth.
- A heightened awareness on the part of both the public and the Government of the need to take innovative action.
- An increase in policy conflicts over alternative uses and allocations of water, water resources, and bodies of water along with their adjacent areas.
- New competing interests for the use of floodplains: commercial and industrial development, housing, the growth of natural and commercial recreation areas, the desire for the conservation of natural resources—especially in wetlands—and historical preservation.
- An increasing amount of legislation relating to floodplains and coastal zones.

Demographic Trends

The distribution and composition of the population is a major incentive for social change. The emergence of flood hazards as compelling public issues is largely the result of demographic trends. Some of these trends are:

- More than half the U.S. population lives within 50 miles of the shoreline of an ocean or a Great Lake, and their number is growing annually.
- The continual shifting of the population to coastal zones and riverine floodplains that are subject to flood disasters is aggravating the environmental stresses in those areas. This population mobility -brings a constant stream of new residents, who are unfamiliar with the hazards of a particular area. Since flood disasters tend to occur in decade-long cycles, the existence of risks is not likely to be common knowledge.
- Increasing population density can create pressure to develop marginal hazard areas by, for example, the location of mobile home communities or parks.
- Space for building to meet a growing population is fast-disappearing in areas of almost totally mountainous terrain such as West Virginia.
- When there is heavy industrial development in areas with a diminishing amount of space on which to build but a need to be near the work force, the development of marginally hazardous areas also tends to be promoted.
- The movement of the elderly and retirees, in general, to warm coastal areas, coupled with the recreational demands of tourists, has been responsible for the intense development of these areas. Consequently, the number of people and homes that could be affected by a disaster is increasing.

Trends in the Management of Flood Hazards

The most consistent trend in flood hazards management has been the historical emphasis on structural control and protection measures as the solutions to exposure to a flood hazard. Recent trends have led to challenging the primacy of flood protection by physical methods, and have succeeded in establishing the need for a strategy that combines structural with nonstructural measures. Specific trends include:

- There has been a long-term preference for the use of physical and technological solutions to hazards, rather than of institutional or socio-technological ones. For the most part, flood control, rather than land use management, has been preferred historically. Physical measures are apparently more acceptable since they may bestow financial benefits with little risk to short-term investments. As noted in the following three trends, this situation is changing.
- There is an overall shift in emphasis from so-called structural to nonstructural prevention and protection measures. Closely related to this is a trend toward the integration of physical, economic, and administrative measures for flood hazards management.
- The traditional high priority on relief is shifting to emphasis on mitigation, prevention, and loss reduction.
- Progress is being made in dealing with natural hazards by a variety of legislative and regulatory mechanisms. (Chapters VII, VIII, and Ix.)
- Land use planning is increasingly being used as a tool of flood hazards management.
- There is greater dependence on insurance and -- other indemnification schemes for flood disaster relief.
- There continues to be a considerable lag between the generation of knowledge from research and its application to flood hazards mitigation.

TRENDS RELATING TO NATURAL HAZARDS

While it is useful to isolate flood-related problems in order to address the conflicts they present, it should be kept in mind that flood hazards are part of a larger class of natural hazards. There are a number of similarities in the way natural hazards are perceived and managed. The changes in these perceptions and the responses to them are prompted by many of the same underlying trends. Table 13 presents more general trends in relation to natural hazards in the United States. These trends were identified by OTA staff during the course of preliminary analysis, and were discussed at the workshops.

Table 13.-Trends in Relation to Natural Hazards in the United States

General

1. The loss of life has remained relatively stable over the past several decades. It is not clear to what extent this is attributable to better planning, preparedness, fewer severe events, social factors, or disaster-reduction efforts. This overall trend may not necessarily hold for specific hazards.
2. There has been an increase in property loss. It is not clear whether this reflects actual increases, inflation, better reporting schemes, insurance availability, or other factors.
3. There is a potential for catastrophes of unprecedented size in certain areas, e.g., in coastal zones and in some river basins. These could take thousands of lives and cause many billions of dollars in property damage.
4. Public policy continues to promote the potential for catastrophic life and property loss by permitting—if not actually encouraging-the development of fragile, dangerous, or risky terrains. This is particularly so in flood- and earthquake-prone areas.

Management *of* Natural *Hazards*

5. There has been a long-term trend toward the use of physical and technological strategies for dealing with hazards rather than institutional or social-technological ones. Flood control, rather than land use management is usually the preferred measure. Physical measures seem to be politically more acceptable since they may bring financial benefits and minimally dislocate short-term investments. As is pointed out in the four following trends, this situation is changing.
6. There is an overall shift in emphasis from structural. to nonstructural prevention and protection measures.
7. There is a trend in hazards management from the current high priority on relief to mitigation, prevention, and loss reduction.
8. The combination of prediction, control, and loss mitigation measures has reduced the unanticipatable, unplanned for elements in natural disasters. Consequently, they can no longer be thought of as "acts of God."
9. Progress is being made in dealing with natural hazards through a variety of legal approaches.
10. Land use planning is on the increase.

Governmental

11. Throughout government, Federal interaction and intervention in what had previously been nongovernmental or State and local concerns is increasing.
12. There is an increasing Federal role in disaster assistance and indemnification for hazards losses.
13. There is a trend toward the partial transfer of risk burdens for disasters from the Federal Government to lower level jurisdictions and individuals through insurance programs and mandated land use planning. .

Scientific and technical

14. Development of new prediction techniques, particularly dealing with earthquakes and weather-related phenomena such as hurricanes and tornadoes, are creating both new problems and new opportunities. The problems principally have to do with institutionalization of the techniques and the identification of an appropriate management scheme for the undesirable side effects of prediction capabilities.
15. Attempts to control natural hazards are increasing and may be expected to continue, e.g., earthquake control, hurricane modification, hail suppression, fog dispersal, and increasing snowfall.
16. Inadvertent and uncertain modification of weather and inadvertent modification of climate are continuing trends in the United States and throughout the world. Similar trends exist for terrain in terms of modifications of soil characteristics and modifications of land use and water runoff patterns.
17. There is widespread agreement among climatologists that the climate is shifting. The direction of that shift—warmer or colder—and its relation to longer term climate shifts is unclear.
18. Nonatmospheric changes are also occurring, such as a rise in sea level.
19. Man's actions are an increasingly significant component of geophysical and environmental phenomena in the world. In some regions the generation of CO_2 exceeds the local capabilities for assimilation.
20. There is an increasing amount of research on natural disasters and natural hazards. There is. however, no comprehensive or adequately coordinated hazards disaster program. Furthermore, the total volume of research on natural hazards from the point of view of the li fecycle of hazards continues to be very poorly funded.
21. Remote sensing as a technological tool in relation to natural hazards is now well developed. Application and utilization of remote sensing remain to be more effectively institutionalized.
22. The mapping and the collection of hazards-related data are increasing throughout the country.

SOURCE: Office of Technology Assessment.

VI. The Issues

In the previous chapter, trends as a means of understanding and presaging issues and determining policy decisions were discussed. This chapter examines and reviews issues in flood hazards management. (These issues will then be dealt with more specifically in chapter VIII, which deals with the issues of the National Flood Insurance Program.)

PUBLIC POLICY ISSUES

A public policy issue is a fundamental conflict among objectives, goals, customs, plans, activities, or interested parties. Such an issue is not likely to be resolved completely in favor of any extreme position in that conflict. Over the long run, the necessarily temporary resolution of issues by a public policy is likely to move toward favoring one interest over another. Thus, at any given time public policy must strike a fresh workable balance between conflicting forces.

THE ISSUES IN FLOOD HAZARDS MANAGEMENT

The conflicts in flood hazards management fall into seven areas (see table 14).

Equity

1. **Right of private** owners to unrestricted use of their property conflicts with Government's responsibilities.
2. Distribution pattern of costs and benefits from flood hazards mitigation and disaster relief.

There are two key equity issues. The first finds the right of property owners to the unrestricted use of their property in conflict with governmental responsibility to safeguard health, safety, and the welfare of citizens.

The second involves the distribution pattern of costs and benefits from the mitigation of flood hazards and from disaster relief. The central question is whether the distribution should principally involve all local payers and beneficiaries or should cover a broader national base.

State and Local Governments v. the Federal Government

1. Conflict between Federal Government as provider of disaster assistance and insurer against loss and jurisdictional powers of States and local governments.
2. Conflict between decentralization of Federal programs and integrated nature of local programs.
3. Conflict between mandatory elements of Federal nonstructural flood management practices and greater awareness of local needs by States and local governments.
4. Local governments confused by wide variety of Federal statutes related to flood control that have conflicting compliance incentives and objectives.

The conflict between State and local governments and the Federal Government arises from two considerations. The first reflects the constitutional limitation on federalism and the distribution of sovereign power among Federal, State, and local governments. The second reflects the piecemeal, contradictory, and poorly integrated plans and programs of the Federal Government in its dealings with State and local governments.

Lack of Integration Among Federal Programs

1. Different agencies with different functions associated with each aspect of lifecycle of a flood hazard.
2. Competing usage of floodplains; physical development; open space; improve water quality; and wetlands, wildlife, and historical preservation.
3. Conflicting Federal land use programs as reflected in development activities of the Corps of Engineers and the Federal insurance Administration.
4. Federal programs with flood management responsibilities often contrary to historical prodevelopment policies.

There is little integration within the Federal system in terms of agency plans and programs con-

Table 14.–Seven Issues in Flood Hazards Management Summarized

Equity	State and local v. Federal Government	Lack of integration amona Federal programs	Goals conflicts	Means conflicts	Short-term v. long-term interests	Information
1. Right of private owners to unrestricted use of their property conflicts with Government's responsibilities.	1. Conflict between Federal Government as provider of disaster assistance and insurer against loss and jurisdictional powers of States and local governments.	1. Different agencies with different functions associated with each aspect of lifecycle of a flood hazard.	1. There are no specific national objectives for floodplain management against which to measure progress.	1. The traditional ways to control floods are being seen not only as inadequate but also as causing the situation to worsen.	1. Short-term benefits of developing a flood hazard area conflict with longer term risks.	1. Present information about flood hazards is inadequate. New information needed to coordinate research and to develop, sustain, and evaluate programs to mitigate flood hazards. Reluctance to allocate funds for information gathering purposes.
2. Distribution pattern of costs and benefits from flood hazards mitigation and disaster relief.	2. Conflict between decentralization of Federal programs and integrated nature of local programs.	2. Competing usage of flood plains; physical development; open space; improve water quality; wetlands, wildlife historical preservation.	2. Single purpose floodplain management conflicts with multipurpose community developmental, environmental, and social objectives.	2. Conflict between relying on single means, e.g., protecting structures or elevating buildings, rather than integrated multiple means, e.g., regulation, acquisition, and relocation, design and location of utilities, redevelopment, and renewal.	2. Present procedure of Federal planning based on flood that has one chance in a hundred of occurring conflicts with need to determine more suitable standards for long-term planning.	2. Different perceptions of magnitude and immediacy of flood hazards, e.g., Federal v. State and local levels; hydrologist and Federal land manager v. private property owner.
	3. Conflict between mandatory elements of Federal nonstructural flood management practices and greater awareness of local needs by State and local governments.	3. Conflicting Federal land use programs as reflected in development activities of the Corps of Engineers and the Federal Insurance Administration.		3. Inherent political, social, and societal conflicts in transition to approach integrating socioeconomic flood hazards control strategies with engineering strategies.	3. Timelag for new measures to take effect conflicts with urgent need to achieve significant improvements in floodplain management.	
	4. Local governments confused by wide variety of Federal statutes related to flood control, that have conflicting compliance incentives and objectives.	4. Federal programs with flood management responsibilities often contrary to historical prodevelopment policies.				

SOURCE: Office of Technology Assessment.

cerned with flood hazards management. This may be improved by the President's reorganization of Federal agencies responsible for hazards and emergency preparedness.

Goals Conflicts

1. There are no specific national objectives for floodplain management against which to measure progress.
2. Single purpose floodplain management conflicts with multipurpose community developmental, environmental, and social objectives.

There are no clear, action-oriented national goals with regard to flood hazards management. Existing programs that are directed at dealing with flood hazards areas are disorganized and at cross-purposes.

Means Conflicts

1. The traditional ways to control floods are being seen not only as inadequate but also as causing the situation to worsen.
2. Conflict between relying on single means, e.g., protecting structures or elevating buildings, rather than integrated multiple means, e.g., regulation, design and location of utilities, redevelopment, and renewal.
3. Inherent political, social, and societal conflicts in transition to approach integrating socioeconomic flood hazard control strategies with engineering strategies.

The traditional means of flood control are increasingly seen not only as inadequate but also as methods that cause the situation to worsen. Yet, political, social, and institutional conflicts are inherent in any transition to an integrated approach using nonphysical or socioeconomic strategies along with physical or engineering design strategies. Mechanical devices and engineered structures tend to appeal to public officials and others with the responsibility for making decisions because their behavior is logical, consistent, and predictable; they yield easily quantifiable data; they perform their tasks objectively; and they can be put into effect on order.

Short-Term v. Long-Term Interests

1. Short-term benefits of developing a flood-hazard area conflict with longer term risks.
2. Present procedure of Federal planning based on flood that has one chance in a hundred of occurring conflicts with need to determine more suitable standards for long-term planning.
3. Timelag for new measures to take effect conflicts with urgent need to achieve significant improvements in floodplain management.

The short-term benefits of developing a flood hazard area conflict with the longer term risks. In addition, conflicts arise over the calculations of short- versus long-term costs and benefits.

Information

1. Present information about flood hazards inadequate. New information needed to coordinate research and to develop, sustain, and evaluate programs to mitigate flood hazards. Reluctance to allocate funds for information-gathering purposes.
2. Different perceptions of magnitude and immediacy of flood hazards, e.g., Federal v. State and local levels; hydrologist and Federal land manager v. private property owners.

Information about all aspects of flood hazards is inadequate. A policy information base is not available and there is a reluctance to generate it. Research programs are uncoordinated and information is not disseminated in a useful and timely form to all concerned. (Information needs particularly relevant to research and development are discussed further in chapter XI.)

VII. The National Flood Insurance Program

The National Flood Insurance Program (NFIP) is the major Federal vehicle for promoting the nonstructural management of flood hazards. As such it brings many of the issues in chapter VI to the fore. NFIP seeks to promote two interrelated objectives in the Nation's coastal and riverine , flood hazard areas:

- To stabilize and eventually reduce flood losses by stimulating the planning and management of flood hazard areas by State and local governments.
- To reallocate the costs of financial assistance to flood victims from Federal taxpayers to occupants of flood-prone areas through the mechanism of insurance.

These are related goals. Effective management of floodplains will keep losses from continuing to rise, while the federally sponsored flood insurance program is intended to reinforce the management of floodplains by setting insurance premium rates for new structures according to the risks at specific sites.

The flood insurance program is discussed in two parts because of its importance as a major innovation in the public management of flood hazards and their consequences. Background information on the origins and operations of the program and the results of some studies of flood and hazard insurance gathered with the assistance of the Federal Insurance Administration* (FIA) are presented in this chapter. Certain key policy issues that the program now confronts are identified in chapter VIII.

ORIGINS OF THE PROGRAM

The private insurance industry abandoned the coverage of flood losses in 1929. Their decision reflected an accurate perception of the- nature of floods. First, the risk of flooding within known floodplains is certain; the only uncertainty relates to the timing and magnitude of the event. Second, when floods do occur they may cause severe losses in the affected areas; this requires an insurer to maintain sizable cash reserves. Third, premium rates that reflect the actuarial risks in floodplains are likely to be so high that those most in need of flood insurance are discouraged from purchasing it. Consequently, before the advent of NFIP in 1968 virtually no private insurance covered coastal or riverine flood losses.

In the absence of insurance coverage flood victims must turn to the Federal and State governments for the major proportion of their relief and rehabilitation needs. As cited in chapter III, Federal disaster assistance outlays increased from $52 million in 1953 to $374 million in 1966 when NFIP was proposed; in fiscal year 1973, Federal aid jumped to $2.5 billion as a result both of Hurricane Agnes and the flood in Rapid City, S. Dak., the previous year.

Congress in the Southeastern Hurricane Disaster Relief Act of 1965 called for a study of flood insurance as an alternative to ever increasing disaster relief outlays. The U.S. Department of Housing and Urban Development (HUD), recommended that flood insurance, through the mechanism of rate premiums, could shift some of the costs of floodplain occupation to the occupants themselves. In order to attract widespread participation in the program it was recommended that the Federal Government subsidize insurance premiums paid by owners of existing structures in flood-prone areas, but that this subsidy would be inappropriate for new development, which should not be encouraged in floodplains. New structures should be insurable only at full acturial rates, reflecting the actual risk inherent in their location and elevation.

*Richard Krimm, Assistant Administrator of FIA, was particularly helpful in this regard.

[1] U.S. Department of Housing and Urban Development, *Insurance and* Ocher *Programs for Financial Assistance co Flood Victims* (Committee Print No. 43) 89th Cong. 2d sess. (Washington, D. C.: U.S. Government Printing Office, 1966).

This caution was reaffirmed by the 1966 report of the Task Force on Federal Flood Control Policy:

> A flood insurance program is a tool that should be used expertly or not at all. Incorrectly applied, it could exacerbate the whole problem of flood losses . . . It would not be improper to subsidize flood loss insurance for existing property. That might be done, provided owners of submarginal development were precluded from rebuilding destroyed or obsolete structures on the floodplain, however, to the extent that insurance were used to subsidize new capital investment, it would aggravate flood damages and constitute gross public irresponsibility.[2]

Congress heeded this advice. NFIP, as passed in 1968 (Public Law 90-488 Title 13) made the adoption of local floodplain regulations a prerequisite to the availability of flood insurance in any local community. To avoid the charge of "federal usurpation" the form and precise content of such regulations was left to State and local governments. But such regulations must be designed to meet floodplain management criteria established by FIA.

Since 1968, the historical evolution of NFIP (depicted in figure *7)* has been characterized by persistent competition between lofty purpose and practical accommodation. The program as established in 1968 called for the immediate adoption of floodplain management regulations by local communities in order to qualify for the sale of flood insurance to their residents. Although the interdependence of flood insurance and floodplain management appeared theoretically reasonable, NFIP met with little enthusiasm on its adoption. During its first year, only 4 communities out of some 20,000 with flood hazard areas joined the program and only 20 policies were sold. **(See table 15.) ,**

Two deficiencies were remedied in subsequent amendments. Recognizing that most communities lack sufficient floodplain data on which to base substantive regulations, a 1969 amendment (Public Law 91-152) authorized provisional eligibility during an "emergency phase," pending completion of Federal floodplain mapping studies for each community. Satisfaction of the full Federal performance standards was deferred and property owners could purchase a modest amount of flood insurance at subsidized rates even for new structures.

The program was substantially modified by the Flood Disaster Protection Act of 1973 (Public Law 93-234), which specified that no "federally related financing" could be extended to owners of flood-prone property unless they purchased a flood insurance policy. "Federally related financing" has been construed to mean direct Federal funding or subsidy as well as conventional mortgage loans by financial institutions insured or regulated by Federal entities. Thus, the banking industry has become involved with NFIP to the extent that loan officers are required to determine whether property on which a loan is to be secured is flood-prone or not, and to notify the applicant accordingly. (Failure to obtain flood insurance where available results in denial of Federal disaster assistance in the event of a flood).

These two modifications-emergency implementation and compulsory purchase of insurance –have accounted for a sizable increase in NFIP activity. By September 30, 1979, 16,566 communities were' enrolled in the program of which 3,381 were in the "regular phase. " More than 1.6 million policies were in effect covering a total of $60 billion worth of flood-prone structures and facilities. Total claims filed during the life of the program have exceeded 146,000 with about 40,000 of these received since October 1, 1978. Total payments made to flood victims have exceeded $572 million. Flood insurance now exceeds either Federal grants or loans (reduced to the amount of Federal subsidy) as a source of postflood disaster assistance.

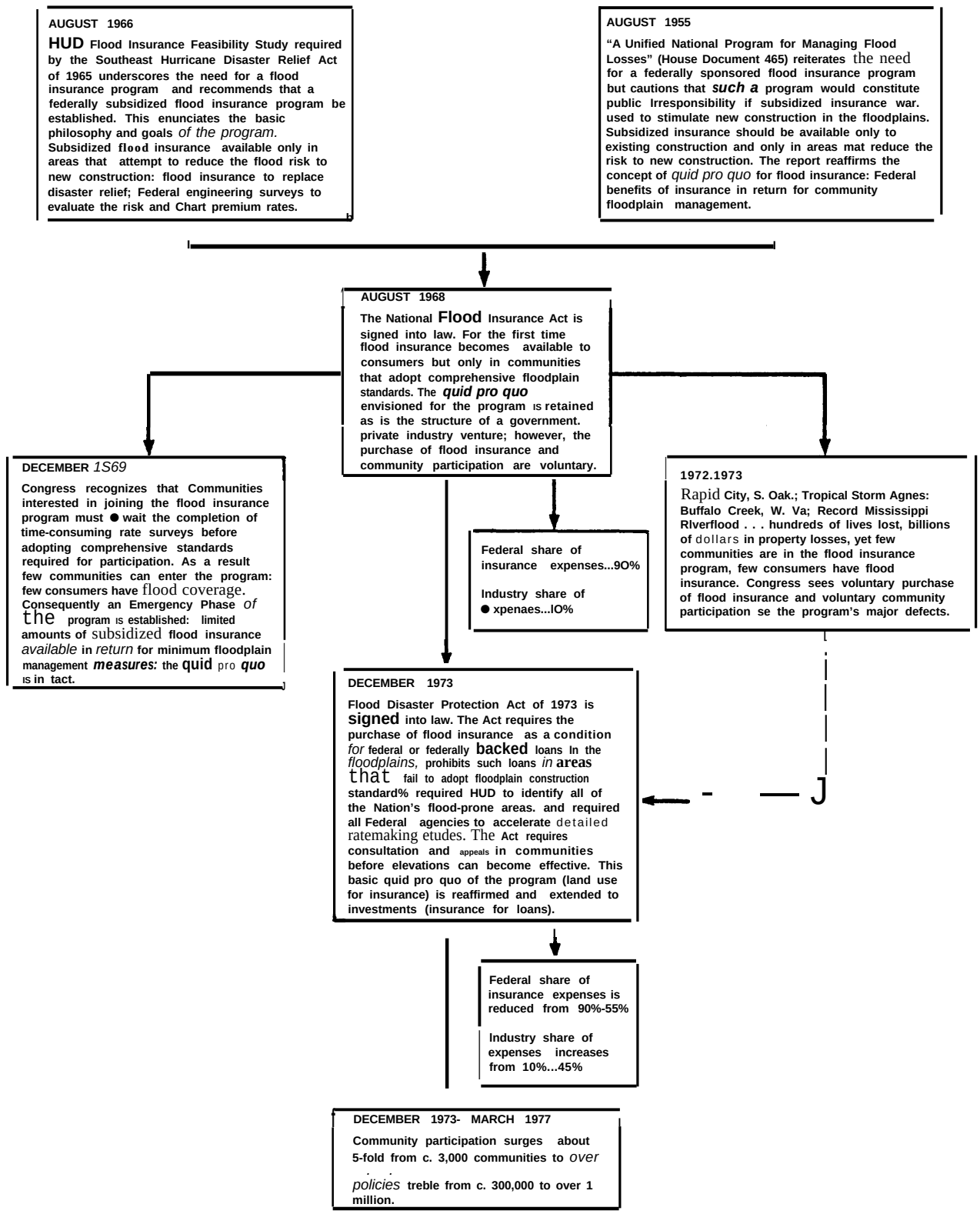
With respect to the approximately 6,000 communities that do not participate in NFIP, a 1977 amendment eliminated the restriction on private mortgage loans to owners of flood-prone property in nonparticipating communities (where the owner cannot obtain flood insurance). Direct Federal assistance under such circumstances remains proscribed, and Federal disaster relief is specifically denied to nonparticipating communities, which remain subject to the terms of the 1973 Act.

THE PRESENT PROGRAM

For the past 10 years NFIP has been administered by FIA, which until the formation of the Federal Emergency Management Agency (FEMA)

[2] Task Force on Federal Flood Control Policy, *A Unified National Region For Managing Flood Losses*, House Document 465 (Washington, D, C.: U.S. Government Printing Office, 1966).

Figure 7.-National Flood Insurance Program's History



SOURCE: Federal Insurance Administration, Department of Housing and Urban Development.

Table 15.-Growth of Coverage Under the National Flood Insurance Program

Date	Participating communities emergency/regular	# of policies	Coverage	Premiums paid	Claims paid
12/31/69	4	16	$ 392,000	$ —	$ —
6/30/69 - 70	158	5,177	83,246,000	373,274	—
6/30/70 -71	637	75,864	1,194,569,000	6,341,893	251,318
6/30/71 - 72	1,174	95,123	1,535,105,000	7,003,383	2,562,806
6/30/72 - 73	2,271	272,448	4,646,835,000	15,315,372	15,007,149
6/30/73 - 74	4,090	385,478	8,463,083,000	25,777,224	36,638,631
6/30/74 - 75	9,625	539,888	13,735,517,000	40,950,701	26,235,018
6/30/75 - 76	14,502	793,779	22,772,837,000	57,524,951	81,359,082
6/30/76 - 77	15,585	1,123,575	33,605,911,000	83,783,715	59,190,026
7/1/77 - 12/31/77	15,770	1,199,749	37,150,208,000	40,235,594	50,887,801
9/30/78	16,100	1,300,000	44,717,000,000	277,306,107	272,131,831

SOURCE: Federal Insurance Administration, Department of Housing and Urban Development.

in June 1979 was part of HUD. Like several other HUD programs, NFIP is characterized by a Federal-local relationship in which the States largely perform a supportive role. The National Flood Insurance Act established a direct working relationship between FIA and the Nation's 22,000 flood-prone areas. Local communities and counties are expected to adopt regulations for the management of their respective flood hazard areas. The rigor and specificity of such measures relates to the quality of information provided to them by FIA-the more detailed the flood hazard maps and studies, the more specific the local regulations should be. Thus, under NFIP there is a phased adoption of floodplain management restrictions by local communities in response to Federal technical assistance. If a community fails to adopt the level of regulation commensurate with available flood hazard data, it is no longer eligible for participation in NFIP and loses eligibility for the further sale or renewal of flood insurance policies within its jurisdiction. Existing policies remain in effect until they expire.

The basic stages of the NFIP partnership between FIA and flood-prone communities is summarized below. A more detailed breakdown is given in table 16, prepared by Illinois for the benefit of its local communities.

No Flood Data

When FIA has provided no local flood hazard information, local communities are expected to require building permits. Before granting a permit, the community should determine whether the site appears to be "reasonably safe from flooding. " If not, structures should be anchored and built of flood-resistant materials. If a subdivision will be flood-prone, utilities should be flood-proofed and adequate drainage should be ensured. The community must also ensure that all State and Federal permits (e.g., wetlands) are obtained by the applicant before a building permit is issued (24 CFR, sec. 1910.3(a)).

Flood Hazard Areas Identified

When FIA has formally identified flood hazard areas within the community (through a flood hazard boundary map), the community must obtain and utilize the best available flood data from any source, to ensure that new residential construction will be elevated above the 100-year flood level (if known), and that nonresidential construction will be flood-proofed to that level. Adjoining communities and the State Coordinating Office must be notified before altering or relocating any watercourse. Mobile homes must be properly anchored and a community evacuation plan should be developed (sec. 1910.3(b)).

Publication of a Rate Map

With the publication of its flood insurance rate map, the community must formally adopt regulations within 6 months that require the elevation or flood-proofing of residential and nonresidential construction above the indicated 100-year flood level (sec. 1910.3(c)).

Determination of Floodway

A "floodway" is that portion of the floodplain required to convey the 100-year flood with no more than a l-foot rise due to encroachment upon adjoining land—the "floodway fringe. " When FIA has determined the location of the floodway, no

Table 16.—Community Progression in the National Flood Insurance Program

Community* not in NFIP*	Community in NFIP's emergency program	Community in Regular program
1. No FHBM, " no requirements, no sane" tions. "	4. FIA* accepts community's application and community enters emergency program.	13. FIA accepts Regular Program ordinance, munity enters Regular -- Program on the effective date on FIS. *
2. FHBM* issued, sanctions* take effect 1 year after initial issue date.	5. Community amends ordinance as the Federal law and/or regulations are amended.	14. Community amends ordinance as the Federal law and/or regulations are amended.
3. Community applies to join NFIP (see "NFIP Local Government Application Procedure," Local Assistance Series 26). Community may apply with or without FHBM, before or after sanctions take effect.	6. FIS* scheduled by FIA to begin 1 to 10 years after joining NFIP.	
	7. FIA schedules time and cost meeting, scope of FIS planned out with community.	
	8. Study review meeting, community officials review draft FIS.	
	9. Final CCO meeting, FIS and regular program requirements explained to the public.	
	10. FIA changes FIS as per comments and appeals from public and community officials.	
	11. FIA issues final elevation determination, FIS is thereby finalized and community has 6 months to pass a regular pro. gram ordinance or be suspended. .	
	12. Regular program ordinance passed and submitted to FIA (may be done during steps 10 or 11).	
Floodplain regulations: Application to join requires passage of emergency Program Development regulation ordinance (See Model NFIP Ordinance).	During steps 4 to 11 community enforces the emergency program development regulations ordinance (see regulations handout and model ordinance).	Community enforces regular program Development regulations Ordinance.
	Failure to adequately enforce the development regulations ordinance may cause suspension.*	
Flood insurance availability: none	Subsidized emergency program flood insurance is available for all property in the community.	Regular program flood insurance rules take effect.
Flood insurance purchase requirements: none	A flood insurance policy may be purchased to cover most Federal grants or loans and most commercial loans and mortgages made for buildings located in areas of special flood hazard* (see insurance handouts).	

*See definitions below.

NFIP—the National Flood Insurance Program.

Community—any local government with the statutory authority to enact and enforce floodplain regulations. In Illinois the term includes only the State government, cities, villages, counties (whose authority only controls unincorporated portions of the county), and special towns (not townships).

FIA—the Federal Insurance Administration in the U.S. Department of Housing and Urban Development.

FHBM—flood hazard boundary map—a map of a community, prepared by FIA, to identify areas of special flood hazard. The map is prepared according to the best flood data available to FIA at the time of preparation. It may be revised as better data is made available to FIA (see handout on how to appeal FHBMs).

Areas of special flood hazard—areas in a community identified on a FHBM or in a FIS. These areas are floodplain lands susceptible to a 1-percent or greater chance of flooding in any given year. A 1-percent chance flood is also known as the 100-year flood or base flood.

FIS—flood insurance study—a study paid for entirely by FIA to delineate the areas of special flood hazard as accurately as possible. The study also produces data on the 10-, 50-, and 500-year floods and sets the regular program actuarial insurance rate zones.

Sanctions—NFIP's sanctions were set by Congress to encourage communities to enact floodplain regulations and join NFIP. Once the sanctions go into effect there will be no new Federal financial assistance for acquisition of or construction in the areas of special flood hazard in the community. Assistance that would be cut off includes Veterans Administration loans, Federal Housing Administration loans, Farmers Home Administration loans, Small Business Administration loans, Environmental Protection Agency grants and loans, community development block grants, and similar direct Federal loans and grants for properties in the floodplain. Federal disaster relief would be denied in the event of a flood, but would be granted after other types of disasters.

Loans from banks, savings and loan associations, credit unions, and other lending institutions may be granted for floodplain properties. However, once the sanctions go into effect, lending institutions that are federally supervised, regulated, or insured (99 percent of them are) have new requirements. These lending institutions must notify applicants for loans for properties located in areas of special flood hazard that there is a flood hazard and that, in the event of a flood, there will be no Federal disaster aid.

Suspension—a community in NFIP may be suspended for failure to adequately enforce its emergency program or regular program ordinance. A community will automatically be suspended for failure to pass its regular program ordinance by the specified deadline. Once a community is suspended, the sanctions go into effect and no more flood insurance policies may be sold or renewed in the community.

SOURCE: Illinois Department of Transportation. Division of Water Resources, Floodplain Regulation Workshop materials, no date.

further fill or encroachment will be permitted within such area (sec. 1910.3(d)).

Coastal Areas

Where FIA has designated a "coastal high hazard area" (V Zone), communities shall require new or substantially improved structures in the V Zone to be located landward of the reach of mean high tide and elevated on piles or columns above the 100-year flood level. Within the V Zone, no new mobile homes are allowed and manmade alteration of sand dunes and mangrove stands is to be forbidden (sec. 1910.3(e)).

The objective of these standards is that communities will prohibit any further fill or encroachment on their regulatory floodway. Outside the floodway, limited new construction will be provided as long as the 100-year flood elevation will not be increased by more than 1 foot. Some States or localities have adopted more stringent rules, allowing encroachment to raise the 100-year flood water height by only 6 inches or not at all. In the latter case, the entire 100-year floodplain is treated as a floodway.

WHAT NFIP HAS ACCOMPLISHED

NFIP is a new and rapidly expanding program. It is therefore too early to assess the Program's effectiveness for reallocating flood losses and for promoting improved floodplain management. Some preliminary NFIP accomplishments are considered below from three standpoints: 1) objective or quantitative measures of program activity to date, 2) informed judgments expressed by experts, and 3) anecdotal evidence from recent flood experience.

Quantitative Data on Program Growth

The rapid growth of the program since its inception and modification is shown in table 15. As of October 1, 1979, 1.6 million policyholders in either the emergency or the regular programs in 16,100 communities were covered for $60 billion. There were 2,262 communities in the regular program. Flood insurance rate studies for 8,691 communities were underway of which 3,147 were completed. Of these 886 were on appeal.

Informed Judgments

- Building codes and practices in flood-prone communities have improved.
- Mapping of the Nation's flood-prone areas has promoted public awareness of flood hazards.
- The program is stimulating consumer purchase of flood insurance in high-risk areas.
- The state-of-the-art has improved in such pertinent subject areas as home construction, economics, environmental engineering, hydrology, and hydraulics.
- The preliminary mapping of flood-prone communities has informed some 19,000 local governments about their flood hazards. (The national objective of completely mapping about 20,000 flood-prone communities by 1983 raises some questions to be discussed below).
- The Flood Disaster Protection Act of 1973, which amended NFIP to provide for compulsory participation and emergency eligibility, succeeded in making the insurance scheme a permanent feature of Federal flood policies, as evidenced by the $60 billion in coverage in effect by October 1, 1979. Although some dissatisfaction has been expressed about filing procedures and delays in the adjustment process, NFIP is realizing its goal of flood loss reduction.

NFIP in Action: Early and Recent Experience

Early experience of NFIP was not promising. When Hurricane Camille hit the Gulf Coast in August 1969, only one community in the State of Louisiana was eligible for the sale of flood insurance. (This situation led to the adoption of the "emergency phase" amendment to NFIP in 1969). In 1972, only 29 policies were in effect in Rapid City, S. Dak., when it was hit by a catastrophic flash flood. Three weeks later only $5 million in flood insurance coverage was in effect in Pennsylvania as compared with an estimated $2 billion in losses caused by Tropical Storm Agnes. Reasons given for the failure of the public to take advantage of flood insurance included.

- Citizens were not aware of the program.
- Agents were not selling the program.
- Local officials were not seeking the eligibility.

- The rates were too high.
- The normalcy bias that "it can't happen to me" deterred interest.
- Central to all major hazards insurance appears to be that 'large numbers of people would not buy the insurance at actuarial rates voluntarily.

The Great Blizzard and Coastal Flood of February 6 to 7, 1978, was the most damaging weather event to strike the northeastern seaboard of the United States since March 1962. Successive high tides driven by winds gusting above 100 miles per hour caused what has been estimated to be a 75-year flood along the Massachusetts coast north and south of Boston. Some 9,000 homes were estimated to have been damaged or destroyed. Over 2,000 were demolished in the towns of Revere, Hull, and Scituate. Additional damage was inflicted on public roads, shore protection works, sewage treatment plants, recreational facilities, and utilities. Damage to automobiles alone was estimated at $23 million, mostly occurring in the coastal area.

For the first time, flood insurance was widely held by flood victims. In 15 of the most severely hit communities in Massachusetts, 3,159 policies were in effect on which 1,663 claims were filed by March 1, 3 weeks after the flood. Payments authorized or actually made as of September 30, 1978 totalled slightly less than $20 million. The Boston Regional Office of FIA provided prompt assistance in processing claims.

The February 1978 storm proved a test of a different sort for NFIP. Among the 15 Massachusetts communities with 30 or more flood insurance claims, 8 were enrolled in the NFIP regular program. Reconstruction of the buildings in those communities that were damaged more than 50 percent must comply with existing regulations for flood-proofing, minimum elevation, and location that reflect NFIP floodplain management standards. This makes it less likely that these structures will be damaged again. It is still too early to state with assurance that NFIP has, in fact, succeeded in mitigating the exposure of coastal investments to repeated loss. Research underway at this time should clarify this question. FIA has made a strong effort, however, to provide technical assistance to the most severely damaged communities to help them direct their reconstruction away from zones of high velocity wave action and to enforce minimum elevation requirements.

In April 1979, a massive flood along the Pearl River in Jackson, Mississippi afforded an opportunity to test NFIP in an inland setting. With fewer than 1,000 policies in Jackson where most of the flood damage occurred, NFIP covered a smaller proportion of losses than in the Massachusetts storm. Nevertheless, FIA launched a pioneering -- effort to employ all available resources to reduce future flood losses. Surveys were undertaken to investigate the feasibility of relocating certain flood victims, and seminars on flood-proofing were arranged. FIA persuaded the Small Business Administration to limit the allocation of disaster loans to sites outside the floodway. As in Massachusetts, the results were not consistent. FIA then developed new approaches that it later utilized after Hurricane Frederick in September 1979.

SOME RECENT STUDIES OF FLOOD INSURANCE

Before turning to the issues in the next sections it would be useful to examine three studies concerned with the behavioral and management aspects of flood hazards that comprise the background for the future evolution of the program.

- Howard Kunreuther of the University of Pennsylvania conducted a 3-year study on insurance protection from the point of view of natural hazards, focusing on flood and earthquake insurance.[3]
- From 1976 to 1977, Jiri Nehnevajsa and others at the University of Pittsburgh studied the preparatory activities that were carried out in anticipation of severe flooding in the Pittsburgh area.[4]
- In 1975, Don Anderson of the University of Wisconsin reviewed the strengths, weaknesses, and accomplishments of the program through 1973. He presented suggestions from a management and insurance perspective.[5]

[3]Howard C. Kunreuther, et al. *Limited Knowledge and Insurance Protection—Implications for Natural Hazard Policy*, University of Pennsylvania, March 1977.

[4]Jiri Nehnevajsa and Henry Wong, *Flood Preparedness 1077:.4 Pittsburgh Area Study,* University of Pittsburgh, May 1977.

[5]Dan R. Anderson, "The National Flood Insurance Program—Problems and Potential," *The Journal of Risk and Insurance*, December 1974, pp. 586-592.

Individual Perceptions and Decisionmaking: The Kunrthuther Study

Howard Kunreuther and his associates at the University of Pennsylvania recently completed a 3-year study on insurance protection from the point of view of natural hazards policy. They focused on flood and earthquake insurance. The study included extensive field interviews of 2,055 homeowners in 43 areas of 13 States subject to coastal zone and riverine flooding, and an additional 1,066 homeowners in 18 earthquake-prone areas in California. Half of the interviewers had purchased insurance and half had not. The field survey was complemented by laboratory investigations of choices among insurance alternatives. Some of the conclusions drawn from this study were:

- The view of the citizen as an "economic man" who makes fundamental decisions such as about purchasing insurance based on maximizing his own utility, is a seriously inadequate model of what happens. Choices are based on what Kunreuther and his associates call a series of contingent claims.
- At the time of the survey, individuals had extremely limited information about floods, earthquakes, and the insurance options available. For example, even among those holding flood insurance, only 17 percent were able to give a reasonable estimate of the cost of the insurance, and only 44 percent could estimate the deductible amount. The awareness of the potential for flood damage shows that the insured had the relatively more pessimistic view. Fifty-five percent of the uninsured expected damage to be $10,000 or less and almost 30 percent expected to incur no damage, whereas among the insured, only 31 percent felt they might incur $10,000 or less. (See table 17.)
- In general, the respondents did not expect to receive aid from the Federal Government should the disaster occur; but rather anticipated that losses would be covered by other sources, notably personal funds.
- Kunreuther's studies sustain the earlier observation made by Robert Kates of Clark University that there is "a major limitation in the human ability to use flood hazard information."[6] Basic reliance is on experience. A person living on a floodplain appears to be strongly influenced by personal experience. There is a widespread inability to conceptualize floods.

[6] Robert Kates, *Hazard and Choice Perception* m *Flood Plain Management*, University of Chicago, Department of Geography, Research Paper #78. As cited in Howard Kunreuther, "Limited Knowledge and Insurance Protection," Public Policy, vol. 2 No. 2, Spring 1976, p. 243.

Table 17.-Individual Perception of Flood Damage

Damage expected to property and contents from a severe flood or earthquake (Qq, 119-122) (% of sample)

Total damage class	Flood survey		Earthquake survey	
	Insured	Uninsured	Insured	Uninsured
No damage	9	29	2	12
$10,000 or less	22	26	13	19
$10,001 to $30,000	37	24	32	27
Over $30,000	24	12	47	34
Unable to estimate	8	9	6	8
Total	100	100	100	100

Subjective probability of severe flood or earthquake causing damage to your home next year (Q. 126) (% of sample)

Subjective probability of flood or earthquake	Flood survey		Earthquake survey	
	Insured	Uninsured	Insured	Uninsured
.10 - 1.00	24	12	7	4
.01 - .10	26	18	63	54
.01 - .00001	20	26	15	15
.00001 or less	13	30	8	17
Unable to estimate	17	14	7	10
Total	100	100	100	100

SOURCE: Howard Kunreuther, "Limited Knowledge and Insurance Protection," *Public Policy*, Spring 1975. pp. 234.235.

The observations, in general, support the following conclusions with regard to the choice to buy insurance:

- A person who is aware of the hazard when he moves into a neighborhood is more likely to be insured than one who is unaware.
- A person who is experienced with flood hazards and whose home has been damaged is more likely to purchase insurance than someone who has not had such an experience.
- The person who has purchased flood insurance is more likely to know someone who has purchased a policy than is an uninsured individual.
- An individual who purchases flood insurance is more likely to have discussed insurance with friends, neighbors, and relatives than is an uninsured individual.
- Kunreuther's key finding is that people refuse to worry about future losses from disasters that they perceive as having little chance of happening. Therefore, it follows that:
  - –Disseminating information is extremely valuable. In one area in New York State, for

example, he finds that individual communities were not properly advised by local leaders about the procedure for joining NFIP because of the political sensitivity of land-use regulations involved.

–The degree of concern about the hazard is likely to be strongly influenced by the way in which risks are presented. Talking about a 100-year flood would obviously have less of a psychological impact than talking about the likelihood of flooding over the next 10 years (one chance in ten).

–The insurance agent plays a key role in the effective delivery of insurance.

–The way in which insurance is marketed is particularly critical in dealing with the poor, the highly mobile, and the aged.

—The significant role of financial institutions is growing by statute since flood insurance is required for all new mortgages in flood hazard areas.

–Coordination with other adjustments to flood hazards is needed.

Response to Warning: The Nehnevajsa Study

Following the severe winter of 1976 to 1977, the University of Pittsburgh Center for Urban Research undertook a study of preparatory activity in anticipation of serious flooding in the Pittsburgh area. They concluded that "given a prior negative experience with the disaster (of the flood type) and realistic warning of an impending flood; given a reasonable time in which to develop ways to prepare for the disaster, public agencies, businesses as well as households become quite motivated to attempt to prepare themselves for the worst . . ."

Much time and effort is spent in activities appropriate for preparing to cope with an impending flood. A majority of the residents in the high risk region had purchased flood insurance, and in 3 additional communities almost half the sample residents had flood insurance. The overall participation fell below 30 percent in only two communities. Furthermore, in all of the communities, businesses tended to carry flood insurance although there was a wide fluctuation in the average amounts reported. Almost all of the residential insurance policies were new. These were purchased in anticipation of the extent of flooding estimated in 1977. Tables 18 and 19 summarize the purchasing patterns.

Table 18.—Flood Insurance: Residents and Businesses Through 1977

	Residents				Businessman		
	Purchased insurance	New policy*	Waiting period*	Average amount	Have flood insurance	Average amount	Businessmen who gave amt.
Allegheny							
Natrona	89.3	70.1	18.5	$19,867	100.0	$ 80,000	(7)
Tarentum	60.7	94.4	0.0	15,290	100.0	87,142	(7)
Sharpsburg	78.7	89.8	3.4	14,386	92.3	34,000	(10)
Millvale	46.7	67.6	16.2	13,833	90.9	53,125	(8)
Monongahela							
McKeesport	29.5	65.2	13.0	13,250	72.7	96,000	(5)
Elizabeth	22.1	66.7	33.3	20,500	71.4	10,000	(4)
West Elizabeth	46.2	52.9	11.8	9,928	80.0	51,667	(3)
Ohio							
Coraopolis	70.7	79.3	13.8	19,900	80.0	70,625	(8)
McKees Rocks	87.8	79.3	12.3	15,036	83.2	8,333	(3)
Neville Island	84.0	87.9	3.0	22,012	76.9	102,500	(8)
Pittsburgh	46.2	87.8	2.4	15,074	87.1	109,687	(16)

*These are percentages of those with policies not of total sample. "New policies" and "waiting periods" do not necessarily add up to 100 percent: the remaining respondents had flood insurance prior to the 1977 winter period.

SOURCE: Jiri Nehnevajsa and Henry Wong, *Flood Preparedness 1977: A Pittsburgh Area Study* (University of Pittsburgh, May 1977), p. 102.

Table 19.-Patterns of Flood Insurance Purchase in 43 Pennsylvania Communities*

Residents without insurance were also asked about their reasons for choosing not to acquire a policy.

- 37.1 percent of these uninsured residents gave general reasons for not carrying insurance—disliking the idea as such, not getting to it, not needing it, and the like.
- 27.6 percent of the residents felt that they did not need insurance because they live on upper floors of homes and apartment houses.
- 14.0 percent felt that they do not live in a potentially impacted area and that, therefore, they would not be directly threatened by flooding anyway.
- 10.2 percent thought that they did not need insurance because they lived in a rented property.
- 7.3 percent could not afford to purchase a policy though they might have done so if money had been available.

In all, 69.0 percent of the residents and 76.2 percent of the businessmen expressed some opinion about the flood insurance program itself:

- 42.1 percent of the residents and 38.5 percent of the businessmen considered it to be a good program.
- 19.4 percent of the citizens along with 17.4 percent of the businessmen believed the program to be "adequate."
- A few additional respondents, both residents and businessmen thought that the insurance rate was favorable, and a few others explicitly stated that they liked the Government's backing of the program.
- Among the negative comments, which in all account for a minority of residents as well as businessmen the following types of concerns appear:
  - —that people don't understand how the program works;
  - —that the program is good mainly for insurance companies;
  - —that it is open to abuse— both by insurance companies - and policyholders;
  - —that the 15-day waiting period is unfair;
  - —that the coverage which the program facilitates ought to be expanded to other items (basement items, carpeting, and the like);
  - -that it does not, in fact, cover the needs of residents or of businessmen adequately at all;
  - —that full value for damaged items is not repayable;
  - -that it should cover a high percentage of reconstruction and rebuilding costs;
  - —that maximum coverage should be increased;
  - —that deduction rates are unfair; and
  - —that business disruption insurance should also be added.
- Furthermore, a few respondents, both residents and businessmen, deferred judgment: they said that the adequacy of the program will best be seen, or prove itself, after actual flooding.

*This study surveyed 43 communities in the Pittsburgh region in the Monongahela, Allegheny, and Ohio Rivers.

SOURCE: Jirt Nehnevajsa and Henry Wong, *Flood Preparedness 1977: A Pittsburgh Area Study* (University of Pittsburgh, May 1977), p. 102.

VIII. Flood Insurance Issues

The National Flood Insurance Program (NFIP) is confronted by a number of issues whose resolution would greatly accelerate the achievement of its objectives. These issues deal with the following problems:

. Reorganization—Transfer to the Federal Emergency Management Agency (FEMA)
- Intergovernmental Relations
  —Within the Federal Government
  –Federal/State: The Texas Landowners Suit
  —Non-Federal Coordination
- The Emergency Program
  —Subsidized Rates for New Construction
  —Mapping of Hazard Areas
- Coastal Hazards and Erosion
- Postdisaster Recovery and Mitigation
- Government as Salesman and Agent for Technology Transfer

Three additional issues concerned with flood hazards regulations and the courts are discussed in chapter X.

- The administration of flood hazards restrictions.
- The technical justification of flood hazards maps.
- The "taking issue."

REORGANIZATION–TRANSFER TO FEMA

During its first decade of operation, NFIP was administered by the Federal Insurance Administration (FIA) as a unit of the U.S. Department of Housing and Urban Development (HUD). Under a reorganization plan submitted by President Carter to Congress on June 18, 1978, FIA has been detached from HUD and reassigned to the new FEMA. FEMA combines five existing agencies and four hazard-related programs. Its purposes are to place Federal emergency mitigation and response activities in one agency, and to provide "one stop" service to States and local governments. More detailed responsibilities are set forth in Executive Order 12148 of July 20, 1979.

Removal from a large cabinet department chiefly concerned with urban development to a small noncabinet agency specializing in emergency management may be expected to have a substantial influence on the future operation of NFIP, but specific implications cannot yet be determined. A major priority for FEMA is to be the mitigation of loss from all natural hazards, especially floods. This should help to improve the performance of NFIP in promoting the reduction of flood losses.

INTERGOVERNMENTAL RELATIONS

Coordination Within the Federal Government

NFIP has not been effectively integrated with other Federal programs and efforts that relate to river basins; to the coastal zone; and to public construction, funding, and licensing activities in general. The decisions of such Federal agencies as the U.S. Departments of Transportation; Health, Education, and Welfare; Agriculture; and Defense; and even HUD, have, however, largely ignored the implications for flood hazards.

The coordination of Federal actions relating to floodplains and wetlands is now mandatory under Executive Orders 11988 and 11990, issued by President Carter May 24, 1977. Each of these orders requires that Federal agencies attempt to minimize the impact of their actions and policies on the areas in question. Executive Order 11988 (reproduced in full in appendix B) states in part:

> Section 1. Each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out its responsibilities for (1) acquiring, managing, and disposing of Federal lands, (2) providing Federally undertaken, financed, or assisted construction and improvements, and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities.

Since the publication of U.S. Water Resources Council (WRC) guidelines on February 10, 1978, 35 agencies have complied with Executive Order 11988 (as of January 1979). It will be several years before any operational effect will be detectable, due to institutional lag time between the introduction of agency floodplain goals and the acceptance within individual programs of these goals. Unfortunately, there are no incentives or sanctions to assure operational compliance with this executive order.

WRC is currently monitoring the re-writing of agency regulations throughout the Federal Government to comply with the executive orders.

A different dimension of the problem involves the failure of certain agencies to give "full faith and credit" specifically to NFIP and to actively assist in the fulfillment of its objectives. The Office of Coastal Zone Management (OCZM), for instance, makes grants to each coastal and Great Lakes State for the development and implementation of State coastal zone plans. In order to receive funding for implementation of a plan, it must be reviewed and accepted by OCZM. This would afford an excellent vehicle for the promulgation of NFIP floodplain management standards for coastal areas. States could be required as a condition to receiving plan implementation funding (under section 306 of the Coastal Zone Management Act of 1972) to consistently regulate, according to NFIP standards, all coastal hazard areas within their jurisdiction. This could be accomplished either through the local adoption of regulations, through statewide controls, or through a combination of both.

This opportunity for promulgating NFIP coastal standards through State coastal zone plans has been largely ignored. After 4 years of discussion OCZM and FIA have failed even to produce an interagency memorandum of understanding. Other similar opportunities to accomplish multiple program objectives through closer coordination may be identified. Some Federal actions and programs that impinge on floodplain management or that share some common goal with NFIP are:*

- amendments to section 404 of the Federal Water Pollution Control Act Amendments of 1972 that relate to Federal licensing of encroachments on wetlands;
- the coastal zone management program;
- a proposed system of urban rivers with the national scenic and wild rivers program;
- section 406 of the Disaster Assistance Act of 1974, which requires hazard mitigation planning as a condition for Federal disaster aid to local communities;
- new emphasis on nonstructural management within the Corps of Engineers and the soil conservation fund;
- broadened funding of the land and water conservation fund;
- proposals for greenline parks and for national heritage;
- urban recreation study;
- HUD community development block grants;
- Federal Strip Mining Act;
- section 208 of the Federal Water Pollution Control Act Amendments of 1972 concerning areawide waste treatment planning; and
- State and local critical areas programs.

*Jon A. Kusler, unpublished memorandum submitted to OTA Workshop on Flood Hazards, March 1978.

Federal/State Relations

The uncertainty and disagreement over floodplain management goals between State and Federal officials is reflected in the absence of fully effective, integrated State enabling legislation. Unwillingness on the part of local officials to pursue tough regulatory courses could be attributed to the difference with which the magnitude and immediacy of flood hazards is perceived in each institutional setting. The flood program requirements demand that local governments spend money, which they are reluctant to do, and provide technical expertise, which they are unable to do. A lack of consistent access to costly personnel and equipment reduces their ability to monitor and enforce guidelines, thereby aggravating the problem of Federal certification of compliance.

Increasing Federal floodplain development authority in the form of financial sanctions, technical assistance, and other types of leverage, has provoked litigation challenging NFIP. State governments, local jurisdictions, and citizens' organizations have cited financial loss, constitutional standing, and philosophical reservations about "big government." These fundamental reservations have the effect of undermining the legitimacy of the program. The following contentions, which serve only to illustrate the kinds of charges leveled at FIA in current litigation, demonstrate a wide range of alleged negative impacts characteristic of

Federal intrusion in an area of traditional State and local autonomy:

- unreimbursed expenses are incurred as a result of administering, enforcing, defending, and challenging NFIP;
- property tax revenues are reduced owing to the reassessment of property whose value is diminished by being designated as a floodway or a flood hazard area;
- property values for developed and undeveloped real estate are also reduced;
- Federal regulations intrude on the sovereignty of the State, violating the 10th amendment and principles of federalism inherent in the Constitution of the United States;
- designations of flood hazard areas are made without affording due process of law or the opportunity of a hearing to challenge the flood information reports;[1]
- Federal regulations hamper the development of commercial businesses located in floodplains, reducing sales taxes, lodgers taxes, and other revenues from tourism, commerce, and similar revenue-producing activity;
- Federal regulations reduce the population growth needed to amortize and justify community facilities, such as wastewater treatment plants; and
- communities are threatened with inverse condemnation suits by landowners for lost or diminished property value.

These accusations have been expressed directly in a lawsuit filed against FIA by a group of dissident communities and property owners discussed next.

The Texas Landowners Suit.[2]–NFIP is currently under legal challenge by a coalition of plaintiffs consisting of the State of Missouri, 40 political subdivisions in 12 States, and 30 individual landowners and associations of landowners. Their lawsuit seeks to have the mandatory aspect of NFIP declared unconstitutional. The need for Federal flood insurance or in some cases for local floodplain management, is not questioned. Objection is raised, however, to the denial of federally related financial assistance to property owners in communities that do not satisfy Federal floodplain management criteria. It is contended that section 102 of the Flood Disaster Protection Act of 1973 (Public Law 93-234) converted NFIP from a voluntary to a mandatory program, and as such the plaintiffs' constitutional rights are violated.

The U.S. District Court for the District of Columbia in 1977 upheld the constitutionality of" NFIP stating:[3]

> The public safety, health and general welfare favor the Program. There is involved a legitimate national goal. One aspect of that goal is to equitably spread the costs of flood disasters among those landowners who most benefit from publicly funded flood disaster relief. . . The Program does not constitute a taking without the payment of just compensation.

Plaintiffs currently have an appeal filed with the U.S. Court of Appeals for the District of Columbia.

Non-Federal Coordination

In many places, streams constitute boundaries between separate jurisdictions. Elsewhere, they flow from one jurisdiction into another. The result is that river basins and floodplains are a mosaic of political authority wherein each unit of State, regional, or local government has extensive autonomy in its use of the common riverine resource.

The consequences of flooding cut across jurisdictions almost everywhere. Both structural and nonstructural efforts to mitigate flood losses in one jurisdiction may be counteracted by inconsistent actions upstream, on the opposite side, and even downstream in the event of backwatering. Because more reliance is being placed on nonstructural measures such as land acquisition and land use regulation, it is increasingly important that the policies and actions of local governments bordering a common stream should be compatible.

Conflicts that arise among jurisdictions in the management of flood-prone areas may involve:[4]

- whether or not to adopt floodplain management measures,
- the use of structural as opposed to nonstructural approaches,

[1] Jon A. Kusler, private consultant, personal communication, 1978.

[2] *Texas Landowners* Rights *Association* v. Patricia Roberts Harm, *et* aL, U.S. District Court for the District of Columbia, Civil Action 77-1962, 1977.

[3] Ibid.

[4] Rutherford H. Platt, *Intergovernmental Management of* Floodplains, draft report prepared for U.S. Army Corps of Engineers, Office of Chief of Engineers, 1978.

- the degree of protection to be achieved through either structural or nonstructural means,
- the management of natural water storage areas lying in more than one jurisdiction,
- the coordination of regulations,
- the coordination of acquisition or relocation of property, and
- the exercise of extraterritorial powers.

Disputes between units of authority sharing a common floodplain frequently do not emerge until a major flood occurs. Potential areas of conflict remain unrecognized due to the infrequency of serious flooding, the prevalence of structural flood control in many watersheds, and the human tendency to discount events that have a low probability of occurrence. Without effective coordination of the policies and actions of individual units of authority, the possibility of achieving sound use of the Nations's floodplains is seriously jeopardized.

There are a number of existing and potential means to achieve some degree of intergovernmental coordination in floodplain management. At the Federal level these include: the planning procedures established by the Water Resources Planning Act of 1965; the National Flood Insurance Program; the coastal zone management program; the land and water conservation fund; the Soil Conservation Service small watershed program; the Disaster Relief Act of 1974; Executive Orders 11988 and 11990; and the mandatory referral procedures established by the Office of Management and Budget Circular A-95. Interstate compacts may be used to coordinate the actions of multiple States within a watershed. State-level measures include statewide land use planning, State floodplain management programs, shoreland zoning, critical areas regulations, and miscellaneous licensing and permit requirements. Substate regional coordination may be achieved through county governments, special districts and authorities, interlocal agreements, extraterritorial powers, and, when all else fails, through litigation.

THE EMERGENCY PROGRAM

Among 16,100 flood-prone communities participating in NFIP on September 30, 1978, 2,756 were enrolled in the "regular program" with fully established floodplain management measures in effect. The other 13,344 communities were enrolled in the "emergency program," which was enacted in 1969 as an amendment to the original law. Under the emergency program, communities may qualify for the sale of flood insurance (up to certain limits) on fulfilling some simple requirements (see chapter VII). Insurance is sold at subsidized rates during the emergency phase, even for new construction - since the data for calculation of actuarial rates have not yet been provided by FIA.

Subsidized Rates for New Construction

The possible construction actions in the emergency phase are contrary to the goals of NFIP as originally conceived. Virtually no local regulations are required, and new structures are at least partially insured at subsidized rates. For NFIP to successfully reduce future flood losses it is imperative that communities in the emergency phase of the program satisfy the full requirements of the program as quickly as possible. In the words of former FIA Administrator George Bernstein:

> [t is the combination of effective land use controls and full actuarial rates for new construction that makes NFIP an insurance program rather than a reckless and unjustifiable giveaway programs

The adoption of land use controls and the application of actuariaI rates are tied to the completion of "flood insurance rate maps" (FIRM) in each local community. A FIRM depicts the 100-year flood hazards area as determined from computer simulation studies. The hazard area itself is divided into differential zones of risk depending on topographical elevation. These risk zones are used by insurance brokers to calculate the actuarial rates applicable to each location in the floodplain.

Subsidized rates are generally felt to be appropriate for persuading owners of existing structures in hazard areas to join the program and enjoy the benefits of its coverage. There is general agreement that new structures subject to hazards should pay actuarial rates. However, those rates cannot be calculated until the relevant rate maps have been prepared. As a consequence, the present legislation states that actuarial rates are effective after publication of the initial FIRM. FIA has interpreted this to mean that subsidized rates are available for new construction before the FIRM is available. Although it is difficult to obtain the data, the

[5]George Bernstein, from Don P. Anderson, "Development of the Principal Elements of a Comprehensive Catastrophe Insurance System," *CPCU Annals*, September 1975, p. 180.

consequences appear to be that construction has been proceeding in the floodplains and coastal zone with the benefit of subsidized rates. This creates the very kind of situation that the flood insurance program is supposed to discourage. Miller has found that "the availability of flood insurance in a coastal community acts as an incentive to lending institutions to provide direct financing of structures in a known hazard area, " and that the tendency is for insurance to sustain and often increase property values in the floodplain. [b]

Although losses due to moderate floods may be reduced (a public gain) because of NFIP, catastrophe potential may be increased (a public loss) because of higher property values and the increased availability of direct financing for floodplain structures. Extensive fieldwork is necessary to determine the extent and seriousness of this problem, and more importantly, to identify the institutions that are taking advantage of this provision.

Mapping of Hazard Areas

FIA is diligently attempting to fulfill its mandate to map the floodplains of each community so that regulations can be adopted and enforced locally. As of November 1, 1978, 8,691 local studies had been initiated by FIA, most of them under contract with other Federal agencies, river basin commissions, and private engineering firms. Of these, 3,147 have been completed and the rest are still in progress. Priority has been given to those communities where flooding and/or development pressure are most extreme.

This process is expensive and laborious. A perfect floodplain map is almost impossible to achieve since error is bound to accumulate in the process of analyzing flood flow characteristics from stream gauge data. Furthermore, the base maps themselves are subject to error. Flood profiles are more accurate but local communities may lack the capability to apply these data.

The very complexity of the mapping effort is delaying conversion of communities from the emergency to the regular program. Communities are requested by FIA to use "best available information" while awaiting completion of their maps. But most of the emergency phase communities lack any serious floodplain controls, regardless of available information. As suggested in an article in *Water Resources Research* by Dingman and Platt, [7] it would be desirable for NFIP to apply and enforce "quick and dirty" estimates of flood hazard areas for purposes of regulation, pending completion of full-scale studies. They propose:

> For interim protection on larger streams and shorelines and for permanent protection elsewhere it is imperative that quicker and cheaper methods for flood hazard area delimitation be sanctioned by the National Flood Insurance Program. A number of expedient methods have been devised and could readily be adapted as bases for regulation. Different methods would probably be appropriate for different areas, depending on the type of information available and the hydrologic and land use conditions.
>
> The Flood Hazard Boundary Maps, produced by the NFIP, are already in the hands of local communities. If amended to eliminate gross errors, these could be used locally until better information arrives. It is illogical to consider these maps to be legally sufficient for determining who must buy flood insurance but inadequate to identify which land should be subject to floodplain restrictions.
>
> Another method long in use at the state level is the use of fixed setbacks from the stream center or bank. Encroachment lines to protect navigability and channel capacity have been sanctioned in the courts [see *Vartelas* v. *Water Resources Board*, 153 A.2d 822, 1958; *Iowa Natural Resources Commission* v. *Van Sant*, 158 N.W2d 111, 1959].
>
> A third technique is to refer to the area inundated by the flood of record (largest flood to have occurred in an area) or other significant historical flood as the regulatory floodplain. This approach is suggested by the state of Vermont for use in areas where other information is lacking and has been used by Massachusetts in its floodplain-mapping program along the Nashua River.
>
> Another approach to delineation involves the use of generalized relations between regulatory flood depth and readily measurable stream and/or drainage basin characteristics . . .
>
> Soils mapping has also been shown to be a useful tool in identifying flood prone areas in some regions [Cain and Beatty, 1968; Parker et al., 1970a, b], and where it exists, it may provide a satisfactory basis for regulation.

[b] H. Crane Miller, "coastal Flood Plain Management and the National Flood Insurance Program, " *Environmental* Comment, November 1975, p. 12.

[7] Lawrence S. Dingman and Rutherford H. Platt, "Floodplain Zoning and Implications of Hydrological and Legal Uncertainty," *Water* Resource Research, Vol. 13, no. 3, 1977, p. 520.

Any of these or other "shortcut" techniques inevitably trade elegance for economy and detail for efficiency. It has been suggested that the elegance and detail of even the most sophisticated floodplain maps may be illusory. But unquestionably, courts are impressed with the sheer cost and weightiness of floodplain reports. Will less impressive techniques pass muster when legally challenged? Recent judicial trends indicate that if a community proceeds in good faith and to the best of its ability to try to protect the lives and investments of its citizens, the law will not stand in the way.

A recent FIA policy change should respond to some needs that have been identified above by FIA staff for work on long-range flood management programs.[8] The main goal is to "allow FIA to concentrate its resources on studying those communities where there is development or development pressure while at the same time providing more in-depth, sustained technical counsel directly to local governments on how to reduce local flood hazards."

COASTAL HAZARDS AND EROSION

The Corps of Engineers in 1971 estimated that 2,700 miles of the Nation's coastal and Great Lakes shorelines were experiencing "critical erosion," with another 17,800 miles incurring "noncritical erosion."[9] A major unresolved policy issue within NFIP concerns the problem of managing coastal hazard areas. In part, this is a mapping problem. Delimitation of coastal hazard areas involves two zones:

- the A Zone, which contains the 100-year coastal floodplains; and
- the V Zone, which is that portion of the A Zone subject to heavy wave action.

The methodology for delimiting these zones is not entirely satisfactory. FIA maps in the past, for instance, have not taken into account storm surge as an element in the calculation of the V Zone. Studies are underway to correct this deficiency.

The management of coastal erosion is itself a major NFIP problem. NFIP regulations distinguish between "rapid erosion," which is an insurable hazard, and "gradual erosion," which is not. Studies by the Great Lakes Basin Commission and others have suggested this to be an unworkable distinction since, for example, a bluff may be undermined gradually, and eventually collapse during a storm. A related issue is whether FIA should establish minimum setbacks based on the vulnerability of a shoreline to erosion. FIA regulations contemplate the delimitation of E Zones based on erosion susceptibility but none have yet been mapped.

Theoretically, NFIP and the coastal zone management program (CZMP) are partners in the national effort to manage coastal areas. The two programs are complementary in their functions. CZMP provides grants for the development and implementation of State coastal zone plans and programs. NFIP supplies minimum flood hazard area management standards. As stated above, however, there has been a failure of coordination between the two agencies. OCZM has not explicitly required States to conform to NFIP standards as a condition for approval of their coastal plans for implementation grants.

Part of the difficulty lies within NFIP where policies towards coastal hazards have not been as clearly defined as in riverine circumstances. Mapping of coastal hazard areas in particular has been a source of problems.

POSTDISASTER RECOVERY AND MITIGATION

An important issue to be addressed by the new FEMA will be the improvement of control over reconstruction after a disaster in hazard areas. This will require close cooperation between Federal and State agencies, especially FIA and the Federal Disaster Assistance Administration. Currently, the potential utility of section 1362 of the NFIP legislation, which authorizes public acquisition of devastated areas following a flood, is being examined.

The Massachusetts Coastal Flood of February 1978 provided an important opportunity to initiate better procedures for postdisaster mitigation. Most of the communities affected were enrolled in NFIP, several of them under the regular program. According to NFIP, rebuilding structures that are damaged beyond more than half of their fair market value must conform with applicable hazard mitigation regulations. The Massachusetts experi-

[8]Gloria M. Jimenez, Federal Insurance Administration, personal communication, Apr. 27, 1978.

[9]U.S. Army Corps of Engineers, *National Shoreline Study*, August 1971. From the abstract.

ence, which is still taking place, should provide information useful for improving mitigation procedures nationwide.

GOVERNMENT AS SALESMAN AND AGENT FOR TECHNOLOGY TRANSFER

Marketing of Insurance

From its inception, until 1977, NFIP operated on a partnership basis with a consortium of insurance companies, the National Flood Insurers Association (NFIA). This arrangement presumably combined the fiscal resources of the Federal Government with the marketing know-how of private enterprise. Communities would be certified by FIA for participation in NFIP according to their degree of floodplain management and NFIA would handle the selling of policies through local insurance agents. In the event of a major catastrophe, the Federal Government would supply the monetary reserves needed to meet heavy claims. (The latter has not been called on since the program's inception.)

In 1977, the FIA-NFIA partnership was terminated by the Federal Government on the grounds that NFIA was not sufficiently accountable and was making too much profit. FIA then employed a private computer firm, Electronic Data Services (EDS), to serve as a "fiscal agent" in the processing of flood insurance policies. EDS is directly accountable to FIA and no private insurance companies are involved, although policies are still sold through local private agents. With over 1 million policies in effect at the end of 1977, covering approximately $37 billion worth of flood-prone property, NFIA apparently made an effective effort to market flood insurance. This effort will have to be sustained and expanded under the new arrangement whereby FIA directly controls the marketing side of the program.

Technical Assistance

FIA is responsible for providing technical assistance to flood-prone communities and private interests to enable them to meet the floodplain management objectives of NFIP. Mapping has been a major element of this task to date. As of November 1978, FIA had initiated 8,691 studies of local flood hazards. Of these 3,147 have been completed and 2,261 communities have been changed over from the emergency to the regular program. FIA is exploring new methodologies including computer graphics and remote sensing (satellite imagery) to speed up this effort and to update maps already issued. Anderson-Nichols, Inc., has been commissioned by FIA to thoroughly review mapping alternatives. This study is subject to oversight by a special committee on flood insurance studies of the National Academy of Sciences under contract to FIA.

An additional element of this function is direct contact between FIA staff and local officials. To date, FIA has maintained about 100 professional staff in nine field offices whose function is to meet with the officials of local communities in order to help them prepare and enforce floodplain management measures. The field staffs are backed up by a small central staff at FIA headquarters in Washington, D.C. These few persons have accomplished a remarkable job in terms of the number of communities contacted. Over 16,000 flood-prone communities have now enrolled in the program, at least on an emergency basis. But the task of converting about 13,000 of these to regular program status during the next few years is formidable.

FIA proposes, therefore, to substantially enlarge its field staffs, possibly to 600 persons nationwide. Furthermore, it is exploring the feasibility of entering into contracts with certain States to fund improved floodplain management programs similar to CZMPS. FIA might possibly establish criteria by which States could be certified, as under the Federal water pollution control program, to administer their own floodplain management programs, relatively free of Federal involvement. The feasibility of pursuing these innovative approaches to technical assistance will depend on the financial support provided by Congress.

It is suggested that the eventual success of NFIP as a vehicle for achieving a reduction of national flood losses will depend directly on the vitality of its technical assistance effort. To date, NFIP has not focused attention on public education concerning risks posed by floods, and options available for prevention, protection, and recovery.

IX. Legal Aspects of Floodplain Regulation in the 1970's

INTRODUCTION

The management of coastal and riverine flood-prone areas through State and local regulation is a comparatively recent phenomenon in the United States. The widespread adoption of comprehensive land use zoning following the 1926 U.S. Supreme Court decision of *Ambler Realty Company v. Village of Euclid*[1] did not involve restraints on the private development of floodplains. As recently as 1953, an authoritative study of flood problems stated:

> Flood zoning, like almost all that is virtuous, has great verbal support, but almost nothing has been done about it. A few local governments have restricted the use of low-lying lands, but not enough for us to point to any substantial amount of experience, or any great degree of progress.[2]

In 1959, a seminal law review article by Allison Dunham "Flood Control Via the Police Power"[3] was unable to cite a single major floodplain zoning decision as of that year.

The long delay in the emergence of floodplain regulation may be explained by three factors. First, Congress in the Flood Control Act of 1936 and its successors declared that the management of flooding would be the responsibility of the Federal Government to be discharged through construction of flood control works. To date, more than $10 billion has been spent in the task of taming the rivers through flood control reservoirs, levees and dikes, channelization and other structural means. Most of this work was performed at Federal expense with little or no involvement by States and local governments. The impression naturally became widespread that flood problems were thus solved, and no further action of a regulatory nature was required. Even where the U.S. Army Corps of Engineers required State or local "assurances" that downstream floodplains would be regulated to prevent encroachment,[4] such assurances have not been widely enforced. A second factor in the slow acceptance of floodplain regulation was uncertainty concerning the constitutionality of such measures. It was widely believed that courts would only uphold restrictions based on precise and unassailable engineering studies. For example, two leading hydrologists Luna Leopold and Thomas Maddock, Jr., wrote in 1954:

> Zoning to restrict the use of floodplain land is . . . complicated. The degree and frequency of hazard vary so greatly that the delineation of zones to which a given restriction will apply should be based on careful study of individual areas, using appropriate engineering information on flood frequency and flood heights.[5]

In the absence of such studies in most communities, it is scarcely surprising that, as the authors noted, "few such laws have been written and tested in the courts. " While the importance of a reasonable basis for any kind of regulation is indisputable, it is perhaps ironic that judicial decisions in other areas of zoning were commonly sustained on the most speculative or questionable planning assumptions. Where loss of life and property were directly at stake, it was widely believed that a higher burden of proof lay with the community.

Reinforcing these two factors, the third reason for the long delay in the adoption of floodplain zoning has been the tendency for communities to avoid politically unpopular measures of this kind. Apart from their hazard potential, floodplains afford level building sites close to transportation systems that follow river valleys. Even where development has little relation to the river it adjoins, floodplains are popular locations for shopping centers, industrial parks, and even housing developments.

The inevitable price of this widespread encroachment of floodplains has been ever increasing flood losses. Despite the expenditure of more than $10 billion in Federal flood control works, average annual flood damages have been rising

[1] 272 U.S. 365 (1926).

[2] William G. Hoyt and Walter B. Langbein, *Floods* (Princeton, N.J.: Princeton University Press, 1955).

[3] 107 *University of Pennsylvania Law Review* 1098-1132 (1959).

[4] President's Water Resources Policy Commission, *Report*, 1950.

[5] Luna B. Leopold and Thomas Maddock, Jr., *The Flood Control Controversy* (New York: The Ronald Press, 1954).

consistently since 1936 to a currently estimated total of $2 billion per year. The loss of lives has decreased in major river valleys due to improved flood warning systems, but is considered to be a major concern in areas subject to flash floods or coastal hurricanes.[6]

Following a series of devastating floods in the mid-1950's and early 1960's, the Nation began to come to its senses. The influential report of the Task Force on Federal Flood Control Policy[7] recommended numerous changes in the national approach to floods. While admitting that structural measures were still needed in certain areas, the report stressed the need for improved use of nonstructural measures including floodplain regulations, flood insurance, and relocation of occupants from flood hazard areas. This report was forwarded to Congress by President Lyndon B. Johnson concurrently with the issuance of Executive Order 11296, which ordered all Federal agencies to consider the flood impacts of their actions. Congress in 1968 established the National Flood Insurance Program (NFIP), which for the first time made floodplain regulation an integral component of Federal policy.

Fortunately, by this time a firm legal basis for the regulation of floodplains was finally in the process of development. No decision by the U.S. Supreme Court has directly addressed the question of floodplain zoning. However, in a 1962 decision involving the regulation of gravel quarries within a residential area, the Court enunciated a general test for the imposition of public authority to abate hazardous situations:

> To justify the state in . . . interposing its authority in behalf of the public, it must appear—first, that the interest of the public . . . require such interference; and, second, that the means are reasonably necessary for the accomplishment of the purpose, and not unduly oppressive upon individuals.[8]

The court went on to reaffirm its traditional view that the legislative determination will be upheld unless clearly arbitrary and capricious.

In the absence of further guidance from the Supreme Court, the evolution of legal doctrine with respect to flood hazards has occurred largely in the State courts with a scattering of Federal decisions. The case law in this area maybe roughly divided into two categories. First, those cases that directly deal with flood hazards per se, either riverine or coastal; and second, those cases that address State and local wetlands regulations in which flooding is an incidental consideration. Both groups of cases involve common questions -- with respect to the "taking issue" as well as matters of technical delimitation and administration. Each group is reviewed below.

THE JUDICIAL RECOGNITION OF FLOOD HAZARDS

In the surprisingly few cases that directly raise the issue, courts have been almost unanimously willing to give explicit recognition to the threat of flood hazards as a proper object of public regulation. In a 1930 case arising in New Hampshire, a Federal court of appeals stated the issue in terms of consumer protection. Where the purchaser of a flood-prone site from the City of Keene object to the subsequent imposition of floodplain restrictions on his use of the land, the court upheld the restraints as a "proper exercise of the City's police power in order to protect possible purchasers being victimized by the City itself."[9] Protection of the unwary buyer or tenant was cited by Dunham as a proper ground for public intervention along with the avoidance of public rescue costs and the protection of downstream interests from the risk of greater flooding due to individual encroachments.[10]

Restrictions imposed following a flood disaster to mitigate future losses were viewed favorably by the Connecticut Supreme Court in 1958.[11] The case involved an "encroachment line" establishment by the State that prohibited all reconstruction within a specified distance of the Naugatuck River upon challenge by a property owner who retained only 60 ft[2] outside of the encroachment line, the court declared:

> Reasonable regulation of the size and area of buildings and the type of material used in them and the method of construction has long been recognized as legal proper . . . The loss of human life and the destruction of property wrought by the floods in August 1955, justified the legislature in conferring upon the commission broad powers to

[6] Gilbert F, White and Eugene Haas, Assessment of Research on Natural Hazards (Cambridge, Mass.: M.I.T. Press, 1975).
[7] *A Unified Program for Managing Flood Losses* (House Document 465), 89th Cong., 2d sess. (1966).
[8] *Hempstead* v. *Goldblatt*, 369 U.S. 590 (1962).
[9] *American Land Co. v. City of Keene*, 41 Fed.2d 484 (1930).
[10] Dunham, op. cit., footnote 3.
[11] *Vartelas* v. *Water Resources Commission*, 153 A.2d 822 (1958).

adopt preventive measures against their repetition. The trial court found that the encroachment lines as established by the commission extend for several miles along the Naugatuck River, in accord with sound engineering principles and statutory requirements, and were designed to reduce hazard to life and property in the event of recurring floods.

The problem of structures erected in violation of applicable encroachment line restrictions was confronted by the Iowa Supreme Court in 1968.[13] The court strongly endorsed the constitutionality per se of such restrictions declaring:

> A river uncontrolled may at flood state become a devil, a destroyer of life and property, a disrupter of transportation and commerce vital to the state and its citizens. [14]

"But the court refused to order the removal of certain levees constructed by the defendant subsequent to the enactment of State floodplain restrictions. Instead, it merely required the filing of an application for a permit. A strong dissent argued that a mandatory injunction for removal should be issued on the ground that such unauthorized encroachment amounts to a "public nuisance. " (A contrasting view is expressed in a Florida coastal wetlands case, where a U.S. District Court ordered immediate removal of fill illegally placed in a Florida bay.[15]

Regulation of flood-prone areas at the local level appeared with increasing frequency after 1960. Perhaps the strongest judicial decision upholding such municipal restrictions was the 1972 Massachusetts opinion in *Turnpike Realty Co. v. Town of Dedham.*[16] Dedham in 1963 had amended its zoning bylaws and zoning map to establish a "floodplain district" that included most of the plaintiff's land in a "low swampy area" bordering the Charles River. Within the floodplain, the use of land was limited to "woodland, grassland, wetland, agricultural, horticultural, or recreational" purposes. Citing the 1959 Dunham law review article and other authorities, the court stated:

> The general necessity of floodplain zoning to reduce the damage to life and property caused by flooding is unquestionable.[17]

In response to the plaintiffs challenge that the ordinance deprived him of any reasonable use of his land, the court replied:

> We are unable to conclude, even though the judge found that there was a substantial diminution in the value of petitioner's land, that the decrease was such as to render it an unconstitutional deprivation of its property.

At the municipal level, conflicting motives and objectives may confuse the floodplain management situation. In *Turnpike Realty,* the ordinance listed among its purposes in addition to the protection of public health and safety from floods, the conservation of "natural conditions, wildlife, and open spaces for education, recreation and general welfare of the public. "[19] The court admitted that such objectives would not support the ordinance in their own right, but that they are merely incidental to the ordinance which is "fully supported by other valid considerations of public welfare." The court distinguished a 1963 New Jersey case[20] in which a municipal wetlands restriction was invalidated on the grounds that it served merely environmental or conservation goals not the alevition of flood hazards.

Clearly an important factor in the willingness of the Massachusetts court to approve Dedham's ordinance was evidence of actual and frequent flooding of the site in question. Testimony of an "expert hydrologist" stated that:

> Petitioner's lands "will have water on it ranging anywhere from practically nothing up to . . . three feet of water annually." He further testifed that once the flow in the Charles River exceeds 1280 cubic feet a second which is equivalent to the approximate elevation of the petitioner's land . . . [the] latter will be flooded. The flow of the Charles River . . . exceeded that level in 1936, 1938, 1955, and 1968. Barrows stated that he personally went to the petitioner's land in March 1968, and observed that it was covered with "approximately four to five feet of water."[21]

Where flooding is recent and notorious, courts may take judicial notice as in the *Vartelas* case.[22] But where the hazard is less obvious, expert testimony of the kind used in *Turnpike Realty* is normally involved. Given such assistance, courts are

[12] 153 A.2d, at 825.
[13] *Iowa Natural* Resources *Council v.* Van *Zee,* 158 N.W.2d 11 (1968).
[14] 158 N.W.2d at 118.
[15] *U.S. v. Joseph* G. *Moretti, Inc.* 331 F. Supp. 151 (S.D. Fla., 1971).
[16] 284 N.E.2d 891 (1972).
[17] Id., at 899.
[18] Id., at 890.
[19] Ibid.
[20] *Morris County* Land Co. v. *Parsippany-Troy Hills Twp.* 193 A.2d 232 (1963).
[21] 284 N. E.2d, at 899.
[22] See footnote 11.

willing to sustain measures of an unusual kind or severity. The California Supreme Court in 1953 upheld a municipal ordinance creating a "beach recreation district" with the benefit of testimony that plaintiffs land on the Pacific shoreline was subject to inundation during heavy storms.[23] A California Appellate Court in 1972 upheld an absolute prohibition of residential or commercial structures in a floodplain upon proof that the site had been flooded four times since 1927.[24] (The zoning in question was adopted in 1965 as a prerequisite to the approval of a flood control project to be constructed by the U.S. Army Corps of Engineers.) The New Jersey Supreme Court in 1966 sustained a total ban on construction of homes seaward of a municipally established "building line."[25] The court rested its judgment on:

> Unrebutted proof that it would be unsafe to construct houses oceanward of the building line . . . because of the possibility that they would be destroyed during a severe storm—the result which occurred during the *storm* of March 1962. Additionally, defendants admitted proof that there was great peril to life and health arising through the likely destruction of streets, sewer, water and gas mains, and electric power lines in the proscribed area in an ordinary storm.[26]

In what must be regarded as one of the most quotable examples of explicit judicial recognition of flood hazards, the New Jersey Court concluded:

> Such recognition prescribed only such conduct as good husbandry would dictate that plaintiffs should themselves impose on the use of their own lands.[27]

Where proof to the contrary is offered, namely that no flooding has been known to occur on the site in question, judicial tolerance of floodplain regulations is more problematic. A Michigan Court of Appeals ruling in 1971 invalidated the application of an ordinance to property where:

> It is uncontested that the plaintiffs land has never flooded and is separated from the flood area by a shallow ditch which plaintiff has prepared to repair, clean, and line with concrete.[28]

The court however upheld the constitutionality of the ordinance as it applied to actual flood hazard areas.

The obvious question arises as to how courts will deal with floodplain zoning where it applies to land that has not been flooded within record but which lies within reach of a flood of estimated probability, e.g., "the 100-year flood." The Federal Insurance Administration (HA) requires communities to regulate such areas as a condition to participation in the regular phase of NFIP. As of September 1978, no known decision has directly addressed this question. However, a 1974 Maryland decision[29] suggests that where a public authority bases its floodplain regulations on computer simulation, that such estimates must be updated in light of actual subsequent flooding experience. The case involved water pollution regulations adopted by the State of Maryland in 1970 that restricted the operation of gravel quarries within a designated "SO-year floodplain." After Hurricane Agnes in 1972, the operator of a gravel quarry brought suit to challenge the constitutionality of the restriction *per se* and its application to his property. The court sustained the overall validity of the measure but agreed that the Department's estimate of the 50-year floodplain should be revised in light of recent experience:

> The Court is aware that'' the date from which the Department's computations were made was derived from storms occurring over the past 40 years, but not Agnes. It is felt that the immediate data resulting from the retention of the Agnes waters forms a more enlightened basis for the determination of the floodplain of Indian Creek.[30]

Plaintiff introduced testimony that Agnes was 1.4 times greater than a 50-year floodplain, even though plaintiffs land was apparently inundated by Agnes. The court rejected an argument by the State that a broader area should be regulated in the expectation of future development in the watershed upstream from plaintiffs land.

A common practice of municipalities that experience frequent flooding is to impose a temporary moratorium on the issuance of building permits pending completion of a master plan or structural flood control project. As in cases involving overloaded sewer systems, courts are inclined to be tolerant of moratoria that are reasonable in purpose and duration. A New Jersey court for example, sustained a moratorium on development in the floodplain of the Passaic River that had been in effect for 2 years pending completion of flood

23 *McCarthy* v. *City of Manhattan* Beach, 264 P.2d 932 (1953).
24 *Turner* v. *County of/De/ Norte, App.*, 101 Cal Rptr. 93 (1972).
25 *Speigle* v. *Borough of Beach* Haven, 218 A.2d 129 (1966).
26 Id., at 137.
27 Ibid.
28 *Sturdy homes, Inc.* v. *Township of Redford*, 186 N.W.2d 43 (1971).
29 *A.H. Smith Sand and Gravel CO.* v. Department of *Water Resources*, *313* A.2d 820 (1974).
30 Id., at 827.

control plans and adoption of permanent floodplain zoning.[31] In 1975, an appeals court upheld the same ban but warned that:

> The line between the exercise of the police and zoning powers on the one hand, and a taking on the other, although not precise may be found in the not too distant future to have been transgressed as to plaintiff's property, unless (the municipality) acts with some degree of expedition to complete the proposed project or to terminate the moratorium.[32]

INLAND AND COASTAL WETLANDS RESTRICTIONS: INDIRECT FLOODPLAIN MANAGEMENT

The proliferation of State and local wetland restrictions in coastal and inland areas has generated a number of judicial decisions beginning in the early 1960's. The cases discussed below differ from those in the previous section in that little or no judicial recognition of flood hazards is expressed. This apparently reflects the absence of any mention of flood hazards as a stated purpose in many wetland statutes. Furthermore, the issue is seldom raised by counsel in the course of wetland litigation.

The nonrecognition of flood implications of wetlands laws is ironic since wetlands are crucial to the mitigation of flooding. Inland wetlands associated with riverine drainage systems serve as natural retention basins retarding flood runoff and reducing flood peaks. The natural valley storage program of the Corps of Engineers in the Charles River of Massachusetts is attempting to protect upstream wetlands in lieu of construction of flood control resevoirs. Coastal wetlands, depending on their location, serve to dampen heavy ocean waves and to provide a buffer between open water and landward development, while tidal marshes do not, of course, include all areas subject to coastal flooding by definition. They are directly subject to periodic inundation by high tides. The filling of coastal wetlands not only destroys the marsh ecology but poses the threat of storm damage to structures located thereon.

Wetland cases arising before 1970 struggled with issues of public purpose and the "taking issue." The leading case holding an inland wetland regulation to be invalid was the 1963 New Jersey decision in *Morris County Land Improvement Company v. Parsippany-Troy Hills Township.*[33] Like many subsequent wetlands cases, the activity in question involved excavation of swampland to be followed by filling and development. By municipal ordinance, this activity was prohibited within a 1,500 acre wetland known as Troy Meadows. The court took note that **75** percent of this swamp was owned by a private conservation organization that had been "energetic and apparently quite influential in urging the local authorities to restrict use of all of the land accordingly."[34] The court held the ordinance to be invalid on the ground that its "prime object . . . is to retain the land substantially in its natural state."[35]

Flood considerations are specifically rejected in a footnote by the court stating:

> There is no substantial evidence in this case that the matter of intramunicipal flood control had any bearing on the adoption of the Meadows zone regulations. It does not appear that the rise in the water level in the Meadows in time of heavy rainfall affected any other area in the township. The emphasis was on permitting that rise in that areas as a detention basin for the benefit of lower valley sections rather than on any effort to prevent or channel it. This case, therefore, does not involve the matter of police power regulation of the use of land in a floodplain on the lower reaches of a river by zoning, building restrictions, channel encroachment lines or otherwise and nothing said in this opinion is intended to pass upon the validity of any such regulations.[36]

This qualification was carefully cited by the Massachusetts court in its *Turnkpike Realty* decision[37] as ground for viewing the *Morris County* case as inapplicable where flooding is in fact a stated public concern. *Morris County* is even criticized in a lower New Jersey court in the 1973 *Cappture Realty* case:

> Increased urbanization and changing circumstances warrant a more sophisticated-approach to flooding problems.[38]

[31] *Cappture Realty Corp. v. Board of* Adjustment *of* the *Borough of Elmwood Park, 313* A.2d 624 (19731

[32] *Cappture Realty Corp. v. Board of* Adjustment *of the* Borough *of Elmwood* Park, 336 A.2d 30 (1975), at 33. See also: *New Jersey* Budders *Association* v. Town *of Ocean,* 319A. 2d 255 (1974).

[33] 193 A.2d 232 (1%3).

[34] 193 A.2d, at 234.

[35] Id., at 239.

[36] Id., at 242.

[37] See footnote 16.

[38] 313 A. 2d, at 633.

Nevertheless, *Morris* County continues to be cited by parties objecting to both wetland and floodplain regulations throughout the country but with little effect.

The taking issue rather than the public purpose has proved to be an obstacle in several other wetlands cases arising in the 1960's. Where the Connecticut town of Fairfield had levied an $11,000 sewer assessment against a wetland parcel, the subsequent inclusion of the property in a "floodplain zone" was held to be "practical confiscation of the land."[39] The court took a patronizing stance on the question of flooding:

> Although the objective of the Fairfield Flood and Erosion Control Board is a laudable one and although we have no reason to doubt the high purpose of their action, these factors cannot overcome constitutional principles.[40]

The same court took a similar position in a subsequent case involving a wetlands restriction by the Town of Old Lyme that allegedly reduced the plaintiffs property value from $32,000 to $1,000.[41] Again, lip-service is paid to the public purpose: "Undeniably, the defendant's objective to observe marshland from encroachment or destruction is a laudable one. The preservation of our natural environment is of critical concern. "[42]

The high courts of Massachusetts and Maine were meanwhile experiencing similar ambivalence. In a 1965 decision concerning the Massachusetts Coastal Wetlands Restriction Act (M.G.L.A. Ch. 130, sec. 27A), the court declared "the protection of marine fisheries is undoubtedly a public purpose . . . . The Legislature clearly has power to protect and preserve the fish and game of the Commonwealth.[43] It was further held that "Broad Marsh is a 'saltmarsh' necessary to preserve and protect marine fisheries."[44] Nevertheless the court expressed concern about the economic effect of restricting dredging and filling in the marsh. The Maine Supereme Court in 1970 similarly granted a property owner's request for relief from the coastal wetland restrictions of that State.[45] The court stated:

> The benefits from its preservation extend beyond town limits and are state-wide. The cost of its preservation should be publicly borne. To leave appellants with commercially valueless land in upholding the restriction presently imposed, is to charge them with more than their just share of the cost of this state-wide conservation program, granting fully its commendable purpose.[46]

The court declined, however, to hold the statute to be unconstitutionally vague, and sustained restrictions on the draining of sanitary sewage into coastal wetlands. Neither this case nor the preceding Massachusetts decision discuss possible flood hazards, although both note that the site in question is within reach of mean high tide before filling.

The year 1970, which began with the signing of the National Environmental Policy Act, proved to be a turning point in judicial handling of wetlands cases. Decisions in many jurisdictions since 1970 have displayed a new willingness to condone severe and even total reduction of economic value as the necessary price of preserving the Nation's dwindling coastal wetlands. In contrast to the ambivalent decisions cited above the courts have, on occasion, been enthusiastic about the virtues and values of wetlands. While the question of flooding remains obscure, there is no question that the national interest in managing coastal floodplains benefits, albeit tacitly, from this new judicial style.

The new era was perhaps most eloquently proclaimed by a Federal court of appeals in the 1970 decision *Zabel v. Tabb:*[47]

> It is the destiny of the Fifth Circuit to be in the middle of great, often times explosive, issues of spectacular public importance. So it is here as we enter in-depth the contemporary interest in the preservation of our environment . . . .
>
> We hold that nothing in the statutory structure compels the Secretary to close his eyes to all that others see or think they see. The establishment is entitled, if not required to consider ecological factors and, being persuaded by them, to deny that which might have been granted routinely 5, 10, or 15 years ago before man's explosive increase made all, including Congress, aware of civilization's potential destruction from breathing its own polluted air and drinking its own infected water, and the immeasurable loss from a silent-spring-like disturbance of nature's economy .48

[39] *Dooley v. Town Planning* and Zoning commission of *the Town of* Fairfield, 197 A.2d 770 (1964), at 773.
[40] 197 A.2d, at 774.
[41] *Bartlett v.* Zoning Commission *of the Town of Old Lyme*, 282 A.2d 907 (1971).
[42] 282 A.2d, at 91 I.
[43] *Commissioner of Natural Resources v. S. Volpe and CO.*, 206 N.E.2d 666 (1965).
[44] Id., at 671.
[45] *State v. Johnson*, 265 A.2d 7 11 (1970).
[46] Id., at 713.
[47] 430 F.2d 199 **(1970).**
[48] Id., at 200-201.

The following year a Federal District Court in Florida ordered a developer to remove fill that had been placed in Florida Bay without obtaining approval of the Corps of Engineers.[49] The opinion discussed in detail the ecological impacts of dredging and filling on mangrove and shallow and estuarine waters. State courts confronted by wetlands issues during the 1970's have generally followed the Federal lead. The Massachusetts court in 1970 upheld the denial of a permit for a property owner to dredge a boat channel through his wetlands. The court sustained both a local by-law and the State Coastal Wetlands Act, holding them to properly operate concurrently .50 To be sure, a boat channel may be regarded as an incidental restraint on the use of the owner's upland property.

The Connecticut court, however, was to sweep away its own prior indecision in a case involving substantial economic issue.[51] It upheld a denial of a State coastal wetlands permit to a proposed industrial subdivision that had already received local zoning approval by the Town of Guilford, stating:

> There can be no question that the plaintiffs wetland would have greater value to him if it were filled. It must be presumed however, that the defendant's denial of the application was based on the standards set forth in the (stature) which require the hearing officer to "consider the effect of the proposed work with reference to the public health and welfare, marine fisheries, shell-fisheries, wildlife, the protection of life and property from flood, hurricane and other natural disasters, . . ."[52]

The court distinguishes its prior decisions in Bartlett and *Dooley,* declaring that there has been no "practical confiscation" of the plaintiff's land in this case.

Outside New England, Maryland, in 1972, upheld a total prohibition on excavation of and gravel within "state wetlands"- areas defined as lying below the reach of mean high tide.[53] The court quoted Justice Oliver Wendell Holmes to the effect that "a river is more than an amenity, it is a treasure. "[54] Rhetorical elegance has also been supplied by the Supreme Courts of New Hampshire and Wisconsin. The former in upholding its State's coastal wetlands act declared:

> The denial of the permit by the board did not depreciate the value of the marshland or cause it to become "of practically no pecuniary value." Its value ***was*** the same after the denial of the permit as before and it remains as it had been for milleniums.[55]

The Wisconsin court in a landmark decision concerning that State's Shoreland Zoning Act stated:

> It seems to us that filling a swamp not otherwise commercially usable is not in and of itself an existing use, which is prevented, but rather is the preparation for some future use which is not indigenous to a swamp. [56]

While the tide of State and Federal wetlands decisions clearly is running in favor of validity, this does not suggest that no further legal issues affect the regulation of floodplains. The necessity for clear standards and fair treatment of permit applicants is illustrated in the protracted Massachusetts case of *MacGibbon v. Duxbury.*[57] Despite its firm acceptance of coastal restrictions expressed in *Golden* v. *Falmouth,*[58] the Massachusetts court in three decisions refused to sustain the denial of a permit for the filling of 4 acres of coastal wetland on the grounds that the local board of appeals had indicated its intent to deny all such applications regardless of circumstances. The 1975 opinion in this case does in fact discuss the coastal flooding and erosion stating that: "We think the board (of appeals) was entitled to consider flooding and resulting erosion in passing on the permit. " However, in response to testimony that flooding and erosion could be mitigated through protective measures, the court held that the board should have imposed suitable conditions rather than denying their permit completely. It appears that the issue of flooding and erosion could have been better presented. In particular, the court did not acknowledge the importance of wetlands in their natural state as a buffer against storm tides. The experience of Massachusetts in February 1978 when some 9,000 coastal dwellings were damaged or destroyed suggests that the mitigation measures discussed in MacGibbons would have been of no avail. The only prudent course is to deter new development at the water's edge.

[49] U.S. v. *Joseph* G. *Moretti,* he., 331 F. Supp. 152 (1971).
[50] *Golden* v. *Board of Selectman of Falmouth,* 265 N.E.2d 573 (1970). But see: *Lauricella* v. *Planning and* Zoning Board *of* Appeals, 342 A.2d 374 (corm., 1974).
[51] *Brecciaroli* v. *Connecticut Commissioner of Environmental* protection, 362 A.2d 948 (1975).
[52] Id., at 952.
[53] *Potomac Sand and Gravel Co.* v. Governor o/ *Maryland,* 293 A.2d 241 *(1972).*
[54] Id., at 248 citing *New Jersey* v. *New York,* 283 U.S. 336(1931).
[55] *Sibson* v. *State,* 336 A.2d 239 (1975), at 243.
[56] *Just* v. *Marinette County,* 201 N.W.2d 761 (1972).
[57] *MacGibbon* v. *Board of Appeals* Of *Duxbury,* 200 N.E.2d 254 (1964); 255 N.E.2d 347(1970); 340 N.E.2d 487 (1975).
[58] See footnote 50.

X. The Roles of Federal, State, and Local Governments

This chapter is a brief review of the Federal system's established and potentially useful future roles in flood hazards management in relation to its own internal directions, and in its relationships to State and local government and the private sector. As new public institutions take initiatives in policy areas that were traditionally influenced by individual decisions or by the decision of local political jurisdictions, roles must be clarified to reduce uncertainty and promote more cohesive program implementation.

FEDERAL ROLES

This report is written from the perspective of Federal actions and options with regard to the floodplain. Therefore, the question of what the Federal role could or should be with respect to each key element involved in flood hazards management is crucial. Some of these elements are:

- Federal agencies;
- State agencies;
- regional agencies;
- county agencies;
- municipal agencies;
- local groups generally favoring development of flood hazard areas (realtors, builders, developers, local banks, local businesses, and some people and companies that migrate into the region);
- local groups relatively opposed or hostile to development (those with a desire for historical or environmental preservation, and those wishing to preserve community amenities by controlling size and growth);
- the majority of local citizens who often seem to have no fixed opinion in the matter, largely because of inadequate information about risks, hazards, and options; and
- local planners and those involved in response to emergencies whose views of local development vary widely.

The Federal relationship to these public and private elements in the flood hazards system should include a minimum of five functions:

- information production and dissemination,
- managing uncertainty,
- financial assistance,
- technical assistance, and
- coordination within the Federal system and with State and local government and the private sector.

Information

The generation and dissemination of information by the Federal Government through its commitment to research and in its central role in pulling together national and international data could be a major factor in flood hazards mitigation.

Uncertainty

Organizing for the purpose of managing uncertainty is an important role of the Federal Government. The uncertainty may be on the part of the private sector concerning investments, on the part of local community about options and opportunities regarding Federal activities, or on the part of citizens at large or individually about their choices and obligations.

Financial Assistance

Traditionally, financial assistance has taken the forms of physical structures for controlling floods and assistance for emergencies and disasters. Even assuming that established levels of assistance have been sufficient, the Federal system is now trying to determine whether those kinds of investments would be best directed to other functions. As the relative roles in land management of the State and, more particularly, local governments increase, the professional and financial limitations of resources in these communities will limit their ability to respond to community needs and to statutory and regulatory demands. Attention should be given to accurately defining the alternative Federal financial assistance, including technical

assistance and training, offered to State and local governments. As suggested below, in the section discussing policy options, attention could also be given to the utilization of flood insurance premiums as one major financial incentive for implementing regulations at the local level.

Technical Assistance

Disseminating information through technical assistance is also an important Federal role. The increased demands on local governments for setting floodplain management standards, and the initiation of such activities and their promotion through the flood insurance program, are hampered by the inadequate size and experience of local professional planning staffs for drawing up, adopting, and implementing floodplain regulations. Local governments, whether assisted directly or through State governments, need continuing technical assistance from State and Federal agencies. An indication of this need is the fact that the Corps of Engineers had approximately 1,000 requests for technical services in 1968. This has grown to over 30,000 in 1977, for a total of 100,000 requests for technical services in guidance during the intervening years.[1] The Federal Insurance Administration (FIA) had only 100 employees nationwide to offer assistance to 16,000 identified flood program communities and 1,700 comprehensive plan adoptees. It would appear that the level of effort is not adequate relative to the size of the problem. Even in the narrower area of early warning, the demands for technical assistance from the National Weather Service seem to exceed, by a significant degree, its ability to respond.

Studies of innovation and change have established that face-to-face personal communication is the single most effective way to deliver information. Federal, State, and local governments are failing to provide this type of direct technical information. There is an immediate need, therefore, to analyze what must be done to provide such information delivery.

Coordination

There is a need to improve Federal coordination of its own programs, and of its programs with State, local, and private agencies. As of mid-1976, there were at least 28 agencies and 9 programs dealing with floodplain management alone.[2] In fiscal year 1974, there were 797 projects involving $795 million, implemented by 11 agencies operating in 44 different legislative authorities. This fragmentation was shown by a Water Resources Council study. (See table 20.)

The Water Resources Council, the principal organization for achieving Federal coordination, finds that "this service has been done most successfully when technical issues are involved as in the case of the flood frequency procedures bulletin prepared by the Interagency Hydrology Committee. " The traditional Federal coordination mechanisms are largely mechanisms for information exchange. It may be that the needed managerial coordination could be achieved under the President's Reorganization Plan for Federal Emergency Preparedness and Response.

Flood hazards management must continue to attend to riverine problems. There are, however, other major opportunities needing attention in metropolitan areas, recreation areas, and the coastal zone. To a great extent, the problems of rural areas are the consequence of poor planning, or the absence of planning accompanied by unchecked, unregulated development. Urban areas, suburban areas, metropolitan fringes, recreational areas and coastal zones, which are continuing to be developed at a relatively vigorous rate, offer opportunities to avoid these historical errors. To implement a long-term plan in new problem areas first may call for interim prohibition of development in questionable areas, and second for positive planning and comprehensive, regulatory management of growth.

In the development of flood hazards management in urban areas, a conflict exists between flood protection and the desire to redevelop urban waterfront areas for such purposes as housing and recreation. The redevelopment of waterfronts is a high-priority community-development project supported by block grant programs in many cities, thus subject to Federal influence. Urban fringes and undeveloped suburban areas at present appear to be giving little attention to hazards or other developmental long-term considerations. Recreational area problems involve second homes to a substantial, but by no means exclusive, degree. It is possible that many people have a lower absolute stake in a second home than they do in their main residence.

[1] Alex Shwaiko, Army Corps of Engineers, personal communication, Apr. 3, 1978.

[2] John A. Kusler, "Discussion Notes" prepared for a Water Resources Council meeting, December 1977.

Table 20.—Federal Elements in Floodplain Management

Federal floodplain management and related programs by agency	Department of Agriculture Agricultural Research Service	Agricultural Stabilization and Conservation Service	Economic Research Service	Farmers Home Administration	Forest Service	Soil Conservation Service	Department of the Army Corps of Engineers	Department of Commerce National Oceanic and Atmospheric Administration	Economic Development Administration	Bureau of Economic Analysis	Department of Health, Education, and Welfare Public Health Service	Department of Housing and Urban Development Community Planning and Development	Federal Housing Administration	Federal Insurance Administration	Federal Disaster Assistance Administration	Department of the Interior Bureau of Land Management	Bureau of Reclamation	Bureau of Outdoor Recreation	Geological Survey	Fish and Wildlife Service	Department of Transportation Coast Guard	Federal Aviation Administration	Federal Highway Administration	Federal Railway Administration	Federal Power Commission	Small Business Administration	Tennessee Valley Authority	Water Resources Council
Flood insurance studies*	—	—	—	—	—	*	*	*	—	—	—	—	—	*	—	—	—	—	*	—	—	—	—	—	—	—	*	—
Floodplain management services	—	—	—	—	—	S	S	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	S	—
Floodplain information studies and reports																												
Riverine	—	—	—	—	S	—	S	—	—	—	—	—	S	F	—	—	—	—	S	S	—	—	—	—	—	—	S	G
Coastal	—	—	—	—	—	—	S	S	—	—	—	—	S	F	—	—	—	—	—	S	—	—	—	—	—	—	G	G
Technical and planning services**																												
Full program	—	—	—	—	S	—	S	—	—	—	—	—	—	F	—	—	—	—	—	—	—	—	—	—	—	—	S	—
Program element	—	—	I	G	I	S	I	S	S	S	—	—	S	—	I	I	—	S	—	S	—	I	I	I	—	—	S	G
Flood modifying construction	—	—	—	G	—	S	S	—	F	—	—	—	—	F	—	—	—	—	—	—	—	—	—	—	—	—	S	—
Flood preparedness, emergency, and recovery	—	F	—	G	S	S	S	—	—	—	S	G	—	S	G	—	—	—	S	—	S	—	—	—	—	G	—	—
Warning and forecasting	—	—	—	—	—	—	—	S	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Research	S	—	S	—	I	—	S	S	S	—	—	—	—	—	—	—	S	—	S	S	—	—	—	—	—	—	—	—
Open space	—	—	—	—	I	S	—	—	—	—	—	G	—	—	—	—	—	G	—	S	—	—	—	—	—	—	—	—

*Administered by the Federal Insurance Administration through reimbursable technical studies by agency shown.
**Land and water resources.

SOURCE: United States Water Resources Council, *A Unified Program for Flood Plain Management*, 1976, p. VI-3.

S—Staff and funds
F—Funds
G—Grants and loans
I—Incidental

THE ROLES OF THE STATES

The States have both a constitutional and, by custom, an essential role in flood hazards management. They are the intermediaries between the national bureaucracies and the local communities. The police powers constitutionally vested in States are basic for using most of the instruments of effective flood hazards management. The new approach to flood hazards management, would integrate the programs and effectively involve regulations, zonings, codes, land acquisition, and land use planning. All of these tools are closely related to State and local government prerogatives backed by statutory police power.

As the size of disasters increase, the States often require assistance to meet their needs. They are the principal agent requesting Federal assistance. For example, the Presidential declaration of emergency or disaster is initiated by a Governor's request for assistance. Emergency response measures must be coordinated at the State level, since local , communities lack the complex infrastructure required to deal with the range of hazards and disasters facing them.

The States are a key element in flood hazards management. They have the option of selectively overriding the local interests of smaller political subdivisions with respect to land use management.

THE ROLE OF LOCAL GOVERNMENT

The local government's role, which is perhaps the most critical to flood hazards management, has relatively the fewest professional, financial, and political resources at its disposal for effectively dealing with problems.

Local government has traditionally been, and still remains, the main target of intervention by short-term parochial interests. Flood hazards management, however, must, of necessity, involve a long-term perspective, thus deferring some short-term benefits. Consequently, the political pressures against effective flood hazards management are particularly strong at the local level. A general sense that growth is good, the desire to improve the tax base, and other local community interests that support building and construction tend to work against long-range planning and management. Local governments are notably lacking both technical assistance and the resources, to identify the crucial problems they face.

The adequacy of regulatory powers of local governments to comply with the floodplain management provisions of the National Flood Insurance Act of 1968 (with subsequent amendments) and the administrative guidelines promulgated pursuant to the Act were studied in a report prepared in 1976 for FIA by J. A. Kusler Associates. J

They found that more than 10,000 cities, counties, towns, villages, and boroughs have initiated floodplain regulatory programs (at least to the extent that they qualified for national flood insurance). In addition, State agencies are authorized in 23 States to directly regulate floodway and floodplain areas, or to establish minimum standards for local regulations.

In general, local units of government and State agencies only possess those regulatory powers expressly granted or necessarily implied by State enabling statutes. Regulations that exceed the scope of such authority are invalid. However, State or local floodplain zoning, subdivision controls, building codes, and other special regulations adopted and administered in a manner that is consistent with enabling authority are likely to withstand legal challenge.

The Kusler study concluded that:

- In some instances, the adoption of regulations has been hindered by a concern that agencies or local units of government lack sufficient power to adopt specific floodplain regulations or broader zoning, subdivision controls, or building codes containing provisions for the reduction of flood damage.
- With minor exceptions, enabling statutes in all States provide sufficient authority for municipal (city and village) adoption of zoning, subdivision controls, and building codes with flood hazards provisions.
- Rural units of government (counties in most States, towns or townships in others) in all but a few States have been delegated sufficient authority to adopt both zoning and subdivision controls with flood hazards provisions.

'J. A. Kusler Associates, *Statutory Lund Use Control Enabling Authority in the Fifty* States, prepared for the Federal Insurance Administration, November 1976.

- Despite generally adequate enabling authority, issues arise with respect to the scope of particular regulations.
- The types of regulations that have been most frequently authorized and employed for controlling floodplain uses at local and State levels are zoning and subdivision regulations, building codes, and other codes.
- Most floodplain regulation continues to take place at the local level. However, States have assumed some measure of direct or indirect State control over floodplain areas in almost one-half of the States. Direct State control through permit procedures has been authorized for dams, floodway uses, and, to some extent, floodway and flood fringe uses. More often States establish standards for local regulation of flood hazard areas but do not themselves directly regulate areas unless local units of government fail to adopt or enforce regulations meeting State standards.
- Forty-three States have expressly authorized one or more classes of local government (e.g., cities, counties) to specifically adopt zoning, subdivision regulations, or building codes for flood hazard areas or drainage control purposes.
- At the State level, 23 States authorize some measure of floodplain regulation or set standards for local regulations.

Intervention in order to reduce the uncertainties associated with flood hazards management programs is a major challenge faced by the Federal Government. Providing technical information directly, clarifying risks and options, enforcing the adoption, principally through the National Flood Insurance Program, of adequate regulatory plans, and attentiveness to the problems and effectuality of compliance, are all necessary and legitimate Federal interventions.

XI. Knowledge Gaps and Research Needs

The purpose of this chapter is to identify what information is needed which, if provided, will assist Congress in policy formulation, legislation, budget allocations, and oversight on flood hazards management.

WHY RESEARCH?

Research and systematic study are increasingly important to the policy process since they are primary tools for understanding complex interrelationships, for effectively gathering empirical information, for defining alternative actions, and for providing a means of evaluating their practicality and effectiveness.

With regard to flood hazards management, there are at least five distinct considerations justifying research:

- The *empirical base* is weak for policy formulation, decisionmaking, and implementation with regard to floods, flood hazards, and flood hazards management. In terms of the dollars at risk, or the total and recurrent Federal commitment, the knowledge base is surprisingly sparse.
- *Reduction of uncertainty* is a primary function of Government, and research is an important tool for providing credible knowledge to those making policy, administrative, and technical decisions.
- *P[anning for research and development* by agencies is fragmented, underfunded, and too limited in scope. Much of the flood hazards research has neither a significant policy focus nor a discernible client.
- *Emphasis on physical problems and measures,* the historical pattern of flood research is continuing in the face of new policy direction toward nonstructural approaches.
- *Criteria of effectiveness* can be major contributions of research, especially as they enable realistic and realizable goals to be set.

Flood hazards research should have a multiagency base. For greatest effectiveness, research units should be located within each agency concerned with flood hazards and the related institutional and economic infrastructure of a flood region. Many agencies, such as the Federal Insurance Administration (FIA) and the Federal Home Loan Bank Board, have, at best, weak internal research units. As a consequence, they cannot adequately define research needs or interpret research results from outside sources that relate flood hazards to their larger mission. The following are the key elements of an adequate policy R&D program.

- Information needs should be determined by the research sponsoring agency for itself while taking the needs of other interested parties into account. These include the executive branch itself, Congress, State, local, and other governmental users, private sector agencies, associations, and individual citizens.
- The plan should be systematic but allow for its own evolution in terms of time, budget, and topical priorities.
- A plan to disseminate timely information effectively and actively to all parties-at-interest must be built into each program and project at its beginning.
- The research plan should consider the utilization of research results, i.e., how to make the information influence public and private decisions.
- Research programs should have their own evaluation plan including explicit criteria, schedules, and mechanisms for correction and feedback.

WHAT IS CURRENTLY KNOWN WITH RESPECT TO FLOOD HAZARDS MANAGEMENT?

Since research is primarily a mechanism for generating knowledge, before turning to specific research priorities, a brief inventory of what is currently known about flood hazards follows:

- The extent of aggregate (national) and (local) exposure to floods, as reflected in mortality, personal injury, and property loss data.

- There are data on the historical frequency and magnitude of floods in many specific flood hazard areas.
- Demographics, economics, and other social studies are well enough understood to be used to identify trends that impinge on floodplain development, uses, and occupancy.
- Past experience, with its strong reliance on structural engineering controls, has shown that nonstructural controls must be introduced and made to work in concert with the engineering approaches.
- There is a large flood insurance program in place that has almost 16,100 participating communities and 1.3 million policyholders indemnified for $43.8 billion. This suggests grassroots support for a program with the proper incentives.

KNOWLEDGE GAPS IN FLOOD HAZARDS MANAGEMENT

There are five main areas where additional knowledge is needed:

- the generation of information,
- the transmission of information,
- the utilization of information,
- the effectiveness of already established hazards-related programs, and
- information gaps in the National Flood Insurance Program (NFIP).

Inadequate information about NFIP is specifically noted because this program plays such a prominent part in flood hazards management.

Generation of Information

Federal disaster research needs to be coordinated. There is no systematic plan across agencies, with the private sector, with State and local governments, and with Congress for identifying information needs for policy setting, program planning, land use management, and engineering design utilization.

- The means are inadequate for identifying and transmitting State and local information needs to the Federal agencies.
- There is little R&D being conducted at the Federal level that could help generate integrated information. Case studies would be useful.
- There is no mechanism for determining what needs to be known to improve flood hazards management.
- There are not enough first-rate researchers in the field due to the lack of steady and adequate support and because there is no sense of urgency on the part of the Federal Government.

Transmitting Information

- There are, at present, no criteria that have been established for determining the relative success or failure of programs over the whole lifecycle of flood hazards.
- The functions of the various components of a delivery system–who should be transmitting information to whom and in what form—have not been clearly determined and assigned at the Federal agency level.
- There is no single information source for the data and information produced by the various Federal technical, planning, and operating agencies.
- The extent to which Federal agencies concerned with flood hazards management should take an active role in gathering information about flood hazards is not clearly mandated.
- There are shortcomings in the dissemination of information, both to the public and to public officials and organizations, about the potentials of flood hazards. The lack of coordination among Federal agencies is responsible.

Use of Information

- The criteria for determining whether there has been a discernible impact on the decision processes of individuals and organizations have not been established.
- What are the ways in which the utilization of information differs from its dissemination and transmission?
- The absence of programing and policy goals and the lack of a client orientation undercut attempts at full utilization of information, even when available.

The Effect of Long-Established Hazards-Related Programs

There is an almost complete lack of a useful knowledge base about the extent to which hazards are affected by such agencies as the Corps of

Engineers, the Federal Disaster Assistance Administration, the Small Business Administration, or those more remotely connected but potentially important agencies such as the Federal Home Loan Bank Board, the Federal Housing Administration, and the Veterans Administration. Similarly, the effects of the mortgage industry, insurance companies, and builders, are not known.

Flood Insurance Program Information Gaps

- Who purchases flood insurance, and for what reasons?
- Which communities drop out of the program and why?
- How can Federal agencies relate better to local needs?
- Who at the local level are responsible for identifying the needs and making plans for their communities?
- What is the effect of new construction during the emergency program on the demands on NFIP that will be made in the future?
- To what extent has NFIP reduced or altered the need for disaster assistance? Which communities exemplify this change?

The recent formation of the Federal Emergency Management Agency (FEMA) is a significant step to correct or compensate for the above deficiencies in information generation, transmission, and utilization. (The many critical issues that a new organization faces, which are discussed in detail in a companion paper cited in the preface, suggest that the necessary changes to correct these deficiencies cannot come about without congressional intervention.)

POLICY RESEARCH PRIORITIES

The policy-oriented research topics suggested below would put flood hazards management at all levels of government on sounder footing. The topics relate to six categories:

- planning for flood hazards management,
- integration and coordination of programs and projects,
- warning systems,
- legal issues,
- economics, and
- insurance.

Forty-six study and research proposals are shown in table 21. Rather than being presented in the above categories, they are arranged in relationship to four congressional functions-legislation, policy formulation, budget allocation, and oversight.

Professor Gilbert F. White and his associates at the University of Colorado have proposed a comprehensive flood hazards research program.[1] Their recommendations for areas of research are shown in tables 21 and 22. The recommendations suggested in this report emphasize policy and decision-oriented research. Although some of the subjects noted below have received some research support, on the whole it has been inadequate.

Budget

Use of remote sensing and other advanced data collection techniques.–Remote sensing from space and aircraft, mapmaking using digitalized data storage, and other technologically sophisticated methods of information gathering could provide new and valuable data. Current efforts are largely uncoordinated and inadequately supported.

The long-term (25 to 50 years) merits in**vestigation for—**

- flood insurance with or without regulation and with various levels and patterns of regulation,
- acquisition of flood hazard lands, and
- strategies for flood hazards management.

General cost-effectiveness of alternative mitigation techniques.—The cost-effectiveness of alternative techniques for mitigating flood hazards warrants examination. (This is currently being done in the Connecticut River Basin under section 73 of the Water Resource Development Act of 1974.)

Cost-effectiveness of warning systems.–Warning systems provide information immediately preceding a potential disaster. Additional research is needed to ascertain the costs, benefits, and effectiveness of warning systems.

Funding implementation programs for warning systems in small communities.—Funds are needed to study ways that small-sized

[1] Gilbert F. White, F/_ *Hazard m the* United *States*, Monograph #NSF-RA-E-75-006 (Boulder, Colo.: Institute of Behavioral Science, University of Colorado), p. xviii.

Table 21.-Funding Levels for Research Opportunity Sets

Research opportunities	Current annual level[1]	Suggested additional research in person-years	Time horizon for research
Control and protection works			
Urban sewer and storm drainage	1	100	10
Channel hydraulics	2	50	10
Warning systems and flood-proofing			
Forecasting methods and flood-proofing	1	100	10
Methods of improving warning programs	1	60	10
Flood-proofing technology	0	40	10
Physical and social aspects of flood-proofing	0	10	5
Feedback effects of flood-proofing	0	5	5
Land use management			
Adoption processes	0	30	10
Social effectiveness	1	8	5
Coordination of measures	0	30	10
Insurance, relief, and rehabilitation			
Hazard awareness and insurance adoption	1	?	10
Linkage with land use	2	—	
Compulsory flood insurance	0	5	5
Influence on flood loss potential	0	10	
Relief and rehabilitation impacts	1	50	3-10
Methods of providing relief	0	10	3
Basic data and methods			
Flood frequency estimation methods	3	100	10
Hazard mapping methods	1	25	5
Flood damage variables	1	100	10
Public participation in project choice	1	100	10
Optimal mix of adjustments	1	60	5

[1] 0 = no expenditures or less than $10,000
1 = $10,000-$100,000
2 = $100,000-$1,000,000
3 = $1,000,001-$2,000,000
4 = $2,000,001-$4,000,000

SOURCE: Gilbert F. White and Eugene J. Haas, *Assessment of Research on Natural Hazards* (Cambridge, Mass.: The MIT Press, 1975), p. 251.

communities can adopt suitable warning systems. The requests to the National Weather Service for implementing this objective are apparently beyond its capacity to meet the demand.

Policy

Reassessment of the efficacy of the 100-year flood guideline and study of the implications of alternative standards.-The 100-year flood, which is the present standard in general use for planning, needs re-examination, partitularly with respect to its long-term effectiveness and the desirability of a transition to alternative standards. In addition, the implications of such standards on the various participants in floodplain management, which include planners, engineers, designers, developers, homeowners, and Federal, State, and local officials, should be investigated.

A **handbook of maximum credible flood disasters in each flood-prone region of the United States.–A handbook containing a description of the most serious flood hazards for each flood-prone region of the United States on a State-by-State basis should be prepared. It should particularly emphasize areas of high population density or those subject to extensive flood hazards. There should also bean efficient means for distributing the information.**

Development of options for local governments to accumulate disaster "war chests." –State and local governments could be motivated and assisted by the Federal Government to develop some form of disaster funds.

Preparation of a manual for States to ascertain the cost-effectiveness of different flood strategies.–A manual for State and local governments containing information about costs and benefits in flood hazards management should be one element of the general delivery of information to these governments.

A comprehensive guidebook to Federal grants and assistance for all aspects of disaster planning, response, and rehabilitation. —A guide to Federal grants, aids, and assistance in the form of a regularly issued bulletin would keep

Table 22.-Research Opportunities-Hurricanes

	National aims								Research findings	
	Economic efficiency Reduction of net losses Benefits—costs		Enhancement of human hlth. Reduction of casualties		Avoidance of social disruption		Environ. Protect. or enhance.	Equity Distrib. of costs/ben.	Expected success of research	Likelihood of adoption
Hurricane modification	High	Low-Neg	Hign	Low-Neg	Hìgn	Low-Neg	?	Low	Low	Med
Hurricane dynamics										
Technology										
Socioeconomic effects										
Warning systems	Low	Low	High	High	Med	Med	NA	Med	High	Med
Evacuation methods										
Dissemination and response										
Land use management.	High	High	High	High	High	High	High	Low	High	Low
Hazard mapping method										
Adoption of management										
Socioeconomic effects										
Hurricane-proofing technology adoption										
Insurance.	Med	Low	Low	Low	Low	Med	Low	Med	Med	High
Policy formulation										
Adoption of insurance										
Relief and rehabilitation.	Low-Neg	Low-Neg	Low	Low	High	High	NA	High	Med	Med
Trends, policy, socioeconomic effects										

Med = Medium Neg = Negative ? = In doubt NA = Not applicable

SOURCE: Gilbert F. White and Eugene J. Haas, Assessment *of Research on Natural Hazards* (Cambridge, Mass.: The MIT Press, 1975), p. 250.

those most in need of such information aware of the available help. This, in turn, might serve to encourage improved coordination among the various Federal programs.

One-stop government.–0ne stop in the Federal Government dealing with flood hazards management and information would simplify the efforts of State and local governments and private interests. Attention should be given to alternative ways of setting up specific management, budgetary, and organizational functions to coordinate the flow of information in all directions and to centralize responsibility and authority.

Legislation

The value of integrating the management of flood hazards with the management of other hazards needs further study.

Further use of the "unified national program" approach to identify operational steps for converting concepts into programs and projects.—"A Unified National Program for Floodplain Management" is a Water Resources Council report submitted in response to section 1302 (c) of Public Law 90-448, the National Flood Insurance Act of 1968. This program could be used as the starting point from which to develop additional projects with the cooperation of States, local governments, and others with a stake in the outcome of reducing flood risks in floodplains.

The **integration of flood warning with other natural and manmade hazards warning and information systems merits research.**

Study of the existing authorities of the agencies, police powers, the "taking issue," and tort liability as it applies to the engineering and design professions.-The existing authorities, policies, and activities of Federal agencies as these relate to the lifecycle of natural hazards should be analyzed with the object of identifying their present capabilities with respect to the management of flood hazards.

Alternative decisionmaking and conflict resolution methods.—The necessary flexibility in response to individual circumstances within the framework of maintaining and achieving public policy and statutory goals might be achieved bet-

ter through wider use of arbitration, mediation, or other more flexible judgmental mechanisms.

Oversight

Case histories of successful and unsuccess~ful flood management strategies.–Case histories could help to develop an understanding of the conditions that lead to successful management of flood hazards.

Alternative modes of information delivery.—Face-to-face information delivery, as exemplified by the Agricultural Extension Service, is considered by many to be the most effective way to deliver information on a continuing basis. Further study is needed to determine its applicability to flood hazards.

Effects of specific Federal predisaster, disaster, and postdisaster actions on floodplain management. —Study is needed of the effects on floodplain management and flood risks and losses of Federal actions with respect to flood disasters. The effects of postdisaster aid, relief, and loans programs on future hazards is not well understood, although such measures could reduce future losses.

Alternative decisionmaking arrangements for preparing plans and for the regulation of the floodplain.—A systematic attempt should be made to apply innovative decisionmaking techniques to hazards management.

The perception, interpretation, and use of information about risks by the public-at-large.–Improving the public's understanding of the statistics relating to risks, probabilities, vulnerabilities, and hazards could have substantial payoff in information delivery.

Analysis of the long-term geophysical and environmental phenomena related to floods.-The study of geophysical and environmental phenomena with particular emphasis on the longer term effects would provide a perspective for the next 25 to 50 years. Topics for study include:

- catastrophic flood events,
- shore erosion,
- runoff patterns,
- changing sea levels,
- reservoir sedimentation,
- climate and weather changes,
- urbanization of watersheds and coastal zones,
- aging reservoirs and other fresh and waste water systems, and
- effects of civil works (e.g., dams, levees, and other similar flood control measures).

Review of foreign experience pertinent to the U.S. situation.—The experience of foreign industrialized nations in dealing with environmental hazards similar to those in the United States could be useful. For example, the recent Dutch experience in planning protection of the estuary at Oosterschelee may be applicable to U.S. circumstances. A recent study by the Canadian emergency planning group—"Asset or Liability in Land Use Control" (summarized in table 23) draws many similar conclusions to those discussed in this and other studies concerned with the flood hazards situation in the United States.

The role of the mortgage industry.–The mortgage industry and its regulations have an enormous influence on construction. Studies are needed of the effects of this influence and their implications for flood management policies.

The National Flood Insurance Program (NFIP).–

- actuarial future,
- subsidy and development in floodplains,
- as substitute for disaster assistance,
- choice of participation by individuals,
- retargeting of premiums to local communities,
- gap between adoption and implementation, and
- lessons for other hazards.

In view of the significance of the flood insurance program as part of the national strategy for flood hazards management, the program itself should be subjected to examination, particularly with respect to the following questions.

1. Are the present rates in the regular program considered to be actuarial sound?
2. What is the long-term feasibility of converting the whole program to a folly actuarial, self-sustaining basis?
3. What would be the necessary steps to accomplish this?
4. What would be the benefits and disadvantages to those involved in the program?
5. From the analysis of a series of maximum credible flood disasters, what would be the effect on the program, on communities, the Federal budget, on local economies?

Table 23.-An International Comparison of Flood Hazards: Canada

The following paragraphs are taken from the summary and highlights of the study *Flood insurance—Asset or Liability:*

1. Floods and the threat of flooding are recurring problems in Canada; it has been estimated that floods pose a menace to over 150 communities.
2. Despite flood protection programs extended over the past 30 years the average annual flood hazard is now greater than it was before such programs were initiated.
3. Rapid increases in flood damages have been accompanied by increases in the payment of disaster assistance and relief by various levels of government.
4. The rising threat of flood damage is due not so much to an increase in the incidence of flooding as it is to a rise in the development of flood vulnerable land. In a sense, then, inappropriate land use is a major factor contributing to the increases in flood damage.
5. Increases in flood damage potential cause escalation in demands for protection from the eventuality y of flooding. The costs for providing structural flood control works are spiraling yet flood damages also continue to increase. Obviously a new and complementary range of measures is required if risk, costs, and damages are to be controlled.
6. The benefits of flood protection accrue to a relative minority of the population but are financed out of "public treasuries." This transfer of income from a majority to a minority has raised a number of questions which ultimately relate to the issue of equitable distribution of costs and benefits.
7. Conventional structural measures aimed at controlling floods and reducing flood damages provide only a short-run prescription which fails to touch the roots of the problem. Longer range, more permanent solutions must also be considered.
8. Inappropriate use of land is one of the key reasons for the increasing incidence of flood damage and the rises in flood hazard. Social, economic, and political goals often conflict with each other and with the mix of land uses. Evidence indicates that present trends will persist unless appropriate land use measures are introduced. In the study at hand "floodplain management" is an important aspect of land use control.
9. Reduction of flood risk and flood damages requires a rational mix of both structural and nonstructural measures. Insurance is presented as a strategy aimed at balancing this mix and achieving stated objectives. Carrying the flood insurance strategy one step further it is suggested that comprehensive disaster insurance also merits investigation.
10. Measures for reducing flood damage are not standardized across the country. Because they are derived from different sets of rules and regulations the magnitude of the problem varies from region to region. The existence of rules and measures is in some areas a reflection of the existence of a flood problem while in other areas their absence may serve to aggravate the flood situation.
11. Many flood-related programs are directed at relief rather . than at control or prevention. Although it is recognized that such "ex post facto" measures have a valuable function it is also recognized that they tend to instill apathy in the minds of individuals resident in flood-prone areas. A central issue related to whether or not individuals should be asked to pay for a share of the risks they assume. Associated with the above is the more complex problem of how such measures could be implemented. Insurance is presented as one possibility.
12. If the present range of insurable items were expanded (on a national scale) to include insurance of houses and property (for example) against flooding then these items would no longer be eligible for ad hoc disaster relief (except under conditions of extreme hardship). Through a standardized insurance program people would thus be asked to pay for some of the risk they assume.
13. A crucial question related to how people can be convinced that the insurance strategy is a viable alternative (given that it is). How can individuals be "encouraged" to take out flood or perhaps disaster insurance policies? What range of choices or alternatives are available?
14. Before actuarial rates can be assessed on a sound and standard basis it is necessary that flood- or disaster-prone areas be designated and that an adjustable index of "degree of risk" be assigned to relevant areas. The flood hazard mapping program presently being undertaken by Environment Canada has the potential required to fill that need.
15. Further to the above issues is the question of how pee" pie living in disaster-prone areas will react to the availability of an insurance program. Evidence indicates that a system of incentives would be required to aid in marketing insurance policies. Rendering items recoverable by law or insurance ineligible for ad hoc disaster relief programs is one solution. In isolation, however, it is felt that the above mentioned measure would have its greatest impact after the fact. As it is not the aim of a flood damage or hazard reduction program to bankrupt members of the public it is obvious that parallel measures must also be adopted.
16. An example of such a measure exists in the idea that eligibility for federally approved housing loans and grants should be made conditional upon the purchase of disaster insurance. Another possibility rests with refusing loans or grants for development in areas with high flood risk.

SOURCE: Jennifer D. Willis, *Flood Insurance: Asset or Liability,* for Emergency Planning, Canada, April 19?6, pp. 1-2.

6. Is the present insurance program structure, with its provisions for emergency participation, to any significant extent subsidizing the developments of new, vulnerable structures? To what extent is it accelerating the development of the floodplain, coastal zone, and other hazardous areas?
7. Should the actuarial and subsidized rates be more flexible to reflect Federal, State, and local planning needs for flood hazards mitigation, or only for flood losses?
8. To what extent is the insurance program, which is based on historical cases, an effective substitute, a complement, or irrelevant to disaster assistance? An investigation of case histories could shed light on this question.
9. A series of questions relating to the choice by communities to participate or not participate

in the program, and the choice by individuals to buy or not to buy insurance should be examined in the light of aiding agency planning. Variables suggested as warranting examination are:

—physical environment characteristics;
—contextual characteristics-e. g., State regulations;
-demographic characteristics;
—community differentiation-i. e., complexity of organization network;
—political-legal characteristics;
—cultural characteristics;
—economic variables;
—community power structure; and
—implementing body characteristics.

10. Are there more effective alternative uses for flood insurance premiums? Should such premiums be reconsidered as resources available to promote and implement flood hazards management? For example, could premiums from a community form the base for its own implementation plan?
11. The gap between the adoption of a flood management program and its implementation could be enormous. The promises implicit in a program plan frequently fail to become explicit in action. This subject merits close continued review at the individual, county, and municipality levels.
12. The experience and knowledge gained with the **flood insurance program should be examined in the light of their applicability to dealing with other natural hazards as well as with manmade hazards.**

Effects of relocation on business.

Examination of the land acquisition question.—Altering population patterns in areas particularly prone to flood hazards, which are intensively developed, could be a long-term approach to reducing the risks of disasters. One approach would be land acquisition by Federal, State, and local, or private agencies. An examination of historical and contemporary projects for land acquisition could help identify appropriate data on which to base a three or four decade-long national program.

Microeconomic evaluation of impacts of floodplain management.–Questions about which homeowners and businesses, under what circumstances, would be able or unable to pay the cost of meeting alternative levels of floodplain management regulation or changed construction costs, modified taxes, flood-proofing, etc., need to be resolved. The costs and effects of relocating business districts in floodplain communities require investigation. This raises questions of means and sources of financing.

Models for State government programs.– Expanding State roles could be facilitated and enhanced by cooperative programs to develop State model programs for flood hazards management.

Evaluation of agency compliance with flood management objectives.–Federal agency compliance with flood hazards management objectives, Policies, and statutes should be examined to determine whether more oversight and enforcement is needed to achieve effective integration of the actions of Federal agencies. At the State level, the objective should be to work towards integration of Federal activities with State programs.

Opportunities in architectural design related to floods.-New approaches in the architectural design of domestic and commercial structures to make them less prone to flood damage—particularly in such flood-prone areas as coastal zones and floodplains-should be considered. One approach might be to investigate drastically different architectural designs for these areas. The success of Frank Lloyd Wright in designing structures for hillsides gave us the split-level house. Various measures such as contests and competitions to develop designs for domestic and commercial structures specifically for flood plain and coastal zone hazards areas could lead to significant and useful advances in design.

Role of tort liability in flood hazards management.–There is a trend toward accountability in all professions, which is also seen in architecture and engineering. Tort liability is a principal means of activating that accountability. Because architects and engineers make many of the decisions about building design, structural choice, and siting, their potential liability could motivate them to make more prudent decisions. Government and its employees are also potentially liable for failure to adequatel, warn individuals and organizations of their exposure to risk.

Use and limitations of cost-benefit analysis in flood hazards management.—cost. benefit analysis is mandatory in flood control projects under the Flood Control Act of 1936. A re-

evaluation of cost-benefit procedures as used in flood hazards management needs to be undertaken to promote uniform standards and to reduce the potential for misusing this technique by manipulating assumptions about such factors as discount rate, scope of benefits, and cost evaluation of competing projects.

XII. Some Policy Options

In the previous section, information needs were identified in relation to four congressional functions: budget allocation, policy formulation, legislation, and oversight. Most of these needs could be met at the agency level, if stimulated by congressional oversight or by appropriations.

This chapter sets forth some suggested policy options for improving the management of flood hazards. These options are not recommendations but concepts for consideration. The options deal with:

- setting goals,
- land use management,
- a Federal opportunity: leadership by example,
- the National Flood Insurance Program (NFIP) as hazards manager,
- an all hazards approach to insurance,
- the Corps of Engineers' mission, and
- mapping.

SETTING GOALS

The absence of goals specific enough to guide change and to evaluate progress is a major impediment to achieving an integrated strategy for flood hazards management. Three alternative, but not exclusive, goals are suggested below, that would allow standards of accomplishment to be defined and evaluated.

Hypothetical goal I.–The national objective over the next 10 years is to put flood insurance on a fully actuarial basis.

Hypothetical goal 2.–National policy is that over the next four decades population and physical investments in floodplains at the 100-year risk level shall be reduced by 80 and 70 percent, respectively.

Hypothetical goal 3.—The annual losses from floods as part of a national program shall be reduced by 25 percent per decade (in 1975 dollars).

LAND USE MANAGEMENT

Land use management is the most effective tool for managing flood hazards over the long term. Its costs, however, are incurred in the short term and its benefits are deferred and difficult to evaluate. Therefore, it is politically the most difficult measure to implement.

Land use control could largely be used to remove land from residential and commercial use via acquisition by Federal, State, or local governments. Particular attention could be given in flood hazard areas to long-term land acquisition programs over a period of 30 to 40 years. The success of such a program might require a mechanism for freezing land values at some specified date. A plan that spanned 30 to 40 years could minimize the opportunity costs of redevelopment and deal with the question in terms of both the natural hazards lifecycle and the usual turnover time of structures of 30 to 40 years.

Acquisition should also be looked at from the perspective of other land tenure problems, such as those on agricultural land, recreational land, etc. This raises a more general question as to whether the national land tenure system itself might not be a suitable candidate for long-term re-evaluation and restructuring. Flood hazards management alone may be inadequate to motivate a re-evaluation of land tenure. But when viewed as concomitant with other developments such as man-made hazards, environmental concerns, preservation, and recreation, new tenure systems appear to merit consideration.

A FEDERAL OPPORTUNITY: LEADERSHIP BY EXAMPLE

The large number of buildings and structures owned or subsidized by Federal, State, and local government that are located in flood hazard areas offer an opportunity for leadership in planning, siting, design, and construction practices.

A move in the direction of leadership assumption by the Federal Government appears to have been made by Executive Order 11988, May 24, 1977, which in section 1 states:

> Each agency shall provide leadership and shall take action to reduce the risk of flood loss, to

minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out its responsibilities for (1) acquiring, managing, and disposing of Federal lands and facilities; (2) providing Federally undertaken, financed, or assisted construction and improvements; and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities.

THE NATIONAL FLOOD INSURANCE PROGRAM AS HAZARDS MANAGER

At **present, NFIP is a subsidized program that operates locally to monitor the regulatory process. Its function could be expanded to make it the chief instrument by which flood hazards areas would be managed. This could be carried out by utilizing insurance premiums as a financial base for local flood management programs.**

AN ALL-HAZARDS APPROACH TO INSURANCE

An argument has been made for an all-natural-hazards strategy for dealing with the multiple problems caused by natural events confronting man and his works. Such a strategy in which future floods would be incorporated together with other potential disasters, is treated more fully in a companion volume to this report, *Confronting Nature: A Preliminary Analysis of U.S. Policy Needs Related to Natural Hazards. The* present policy option focuses on a comprehensive catastrophe insurance program.

It has been noted by Anderson, an insurance authority, **that the present public/private insurance system is fragmented, unfair, costly, inefficient, and without incentives for loss mitigation. Therefore, he has proposed that a comprehensive catastrophe insurance system that** would deal with all of these deficiencies be established. Such a **program** would consist of 13 parts: [1]

. standardized all-risk coverage **for all catastrophe perils except war,**
. broad territorial divisions,
- Federal subsidies,
- coverage for residential and small business properties,
- land use control and loss prevention requirements,
- incentives for participation,
- elimination of Federal disaster assistance benefits for private property,
- full availability of insurance,
- Federal reinsurance,
- establishment of catastrophe reserves,
- adequate limits,
- mandatory deductibles, and
- administration by a combination of the private **and public sectors.**

According to Anderson, these are not independent units, but parts of an overall, interdependent system. The exclusion of any one of them could jeopardize the effective functioning of the overall program.

Anderson notes that the value of a comprehensive disaster/catastrophe insurance program has been endorsed by Dacy and Kunreuther, leading scholars of the disaster insurance field, who have pointed out that:

> If all disasters were incorporated in one package, the large adjusting expense incurred today when the actual cause of damage is determined would be obviated and overall rates could be lowered accordingly.[2]

George Bernstein, former head of the Federal Insurance Administration (FIA), is also favorably disposed to all-risk insurance:

> Not only should classifications of insureds and territories be broadened but so too should coverage through the development of an all-risk policy offering full protection against a broad range of hazards. Under such a policy, all insureds could receive the same enumerated protections against such perils as natural disasters, fire, and theft. The Gulf Coast resident would receive protection against his much-needed hurricane exposure on the one hand and his less-needed crime insurance and earthquake exposure on the other; similarly, the midwest resident could be protected against tornadoes and fire and also against his moderate crime exposure. The eastern urban dweller would, under the same policy, be protected against his serious exposure to crime, fire, and riot, and also have earthquake and windstorm protection. The

[1] Dan P. Anderson, "All Risks Rating Within a Catastrophe Insurance, System," *Journal of Risk* and *Insurance,* December 1976, pp. 629-651.

[2] Howard Kunreuther and D. Dacy, *The Economics Of Natural Disasters* (New York: The Free Press, 1969).

west coast resident would have needed earthquake protection as well as mudslide and crime insurance. All of these residents would be paying for coverages they might not ordinarily purchase, but would be assured of receiving the essential protections that today are inadequately available to them. The pennies paid by policyholders for relatively unessential coverages would create a sufficient premium spread to enable insurers to cover the hazards they currently claim to be uninsurable.[3]

The current FIA administrator, Ms. Gloria M. Jiminez, in commenting on the National Governors' Association's plan for a national disaster assistance fund, pointed out the necessity of including loss reduction elements. She stated that such a plan must meet a number of requirements:[4]

- it must provide for effective loss reduction activities;
- it must provide for maximum participation by the private insurance industry;
- it must pay losses for nondisaster events as well as for those covered by disaster declarations;
- it must provide an appropriate transition from a federally subsidized flood insurance program;
- it must protect insurers against catastrophic losses; and
- it must make the insurance coverage available to all property owners, without discrimination.

THE MISSION OF THE CORPS OF ENGINEERS

The historically key role of the Corps of Engineers in flood control civil works, coupled with the undoubtedly continuing need for such civil works, creates both a problem and an opportunity. The problem is how to enjoy the benefits of civil works while effectively integrating them with other strategies.

Consequently, there may be some major value in a broadly based examination of the historical role, successes, and shortfalls of the Corps' civil works programs with a view to recommending modifications of practices, custom, staff, orientation, etc. This topic might be suitable for an 18-month commission on the future of the Corps of Engineers.

MAPPING DELAYS AND ALTERNATIVE ENTRY POLICIES

Mapping is a legislatively mandated prerequisite for joining the regular NFIP. Accomplishing the mapping is excessively time-consuming as well as extremely costly. This raises the question of whether there might not be some alternative procedure for entering the program more readily. At the same time, the existing structures could be improved. At some future time, the terrain could be reclassified to a riskier status.

A 1976 General Accounting Office study emphasized the formidable mapping problems in order to meet the statutory objective.[5] That study emphasized the need for accelerating the process of mapmaking. This option, however, suggests the possibility of proceeding more slowly with mapping, but building an organizational backup permitting the upgrading of regulations in certain areas as knowledge becomes fully developed.

The necessity to simplify the mapping requirement has been discussed by Dingman and Platt.[6] They suggest a number of possibilities:

- The flood hazard boundary maps, produced by NFIP, are already in the hands of local communities. If amended to eliminate gross errors, these could be used locally until better information arrives.
- A method long in use at the State level is the use of fixed setbacks from the stream center or bank in the case of small streams and creeks.
- Refer to the area inundated by the flood of record (largest flood to have occurred in an area) or other significant historical flood as the regulatory floodplain.
- Use the generalized relations between regulatory flood depth and readily measurable stream and/or drainage basin characteristics. Such an approach, using drainage area, stream width, and stream slope (measured

[3] George Bernstein, from Dan P. Anderson, "Development of the Principal Elements of a Comprehensive Catastrophe Insurance System," *CPCU* Annuls, September 1975.

[4] Gloria M. Jimenez, Federal Emergency Management Agency, personal communication, Apr. 27, 1978.

[5] Report to the Congress by the Comptroller General of the United States, *Formidable Administration Problems Challenge Achieving National Flood insurance Program Objectives*, Apr. 22, 1976, pp. 15-36.

[6] Lawrence S. Dingman and Rutherford H. Platt, "Floodplain zoning and Implications of Hydrological and Legal Uncertainty," Water Resource Research, vol. 13, No. 3 (1977), p. 522.

from topographic maps) as independent variables, was proposed in 1961 in Pennsylvania.

- Use normalized curves to estimate flood discharges and stages that reasonably correlate with regulatory flood stages estimated by traditional methods.
- The mapping of soils has also been shown to be a useful tool in identifying flood-prone areas in some regions.

Any of these or other "shortcut" techniques inevitably trade elegance for economy and detail for efficiency. It has been suggested that the elegance and detail of even the most sophisticated floodplain maps may be illusory. But unquestionably, courts are impressed with the sheer cost and weightiness of floodplain reports. Will less impressive techniques pass muster when legally challenged? Recent judicial trends indicate that if a community proceeds in good faith and to the best of its ability to try to protect the lives and investments of its citizens, the law will not stand in the way.[7]

[7] Ibid.

Appendix A: Coastal Erosion

Coastal erosion, a relentless geophysical process is irreconcilable with the present expanding use of the shoreline. The Corps of Engineers considers coastal erosion to be "critical" along 2,700 miles of coastline, especially on the Atlantic coast and Great Lakes shore area. Average annual losses are in excess of $300 million. It is estimated that more than 25 percent of the U.S. coastline is exposed to a variety of wind, wave, and water phenomena: hurricane surge, tsunami, seiche, erosion, scour, undermining, wave impact, landsliding, liquefication, and normal annual cycles of rainfall and storms. [1]

In the face of social, economic, and demographic trends pointing toward the continuing desirability of coastal development, researchers have suggested new land management policies for the reduction or control of widespread shoreline loss.

Knowledge about the complex processes that take place along the shoreline is inadequate. Consequently, scientists have been unable to suggest appropriate public policy responses to the problem. For example:

- It is not clear to what extent coastal erosion is a product of short-term events, such as storms, hurricanes, etc., or to long-term geophysical change. The former suggests a possible role for actuarial indemnifications, prudent land management, setback provisions, and public acquisition. It would not seem practical for public policymakers to expend limited resources, in the latter case, to buy time in the face of a dynamic, evolutionary, and inevitable shoreline erosion process.
- In attempting to evaluate the effects of specific events on erosion, research scientists find shortcomings in current measurement techniques. It is very difficult to quantify the loss from a single meteorological event, unlike those events that have their greatest damage impact on buildings, highways, and services.
- Since a large proportion of affected shorelines are privately owned (for example, the 3,000-mile Michigan shoreline is 82 percent privately owned), options for policymakers seem to be limited to mitigation policies that do not challenge traditional rights of ownership. In this regard, coastal erosion faces problems similar to those in flood management, since legal precedents have not been clearly set for public intervention in some aspects of flood hazards management. Table A- I illustrates one hazards research team's suggestions on needed coastal erosion research. An important feature of these opportunities is the emphasis on long-term commitment to continuing research on fundamental physical and social problems. Although policy measures for coastal erosion have been slow in being affected, the manifestations of human intervention in the runoff-sedimentation process are quite evident. A major dislocation of the sediment balance can be traced to inland structures, such as dams and levees, that have produced the unanticipated impact of upstream soil and sand entrapment. This blockage threatens the useful lifespan of a dam, and forces many coastal communities to maintain beachfronts by dredging and structural protection to augment the decreased amount of natural sedimentation available.

Table A= I.-Research Opportunities- Coastal Erosion

Topics	Level of support: Man-years	Level of support: Duration (years)
Shore morphology	2	
Central data systems	40	10
Socioeconomic loss	5	2
Nourishment/dredging	20	10
Nourishment cost	5	2
Effects of manmade structures	20	10
Remedial structures	40	10
Private adjustments	10	10
EUM programs	26	10
Delineation of risk zones	40	10
Public participation	10	10
Dynamic models of shore change	15	10
Comprehensive hazard insurance	5	5
Total	238	

SOURCE: Gilbert F. White and Eugene J. Haas, *Assessment of Research on Natural Hazards* (Cambridge, Mass.: The MIT Press, 1975), pp. 360-372.

The most striking effects on shoreline sediment and soil processes have resulted from direct development in coastal areas and the unintended impacts of modification of natural sedimentation patterns. Development along the shoreline is increasing, and has contributed to spiraling erosion losses by deforestation, construction, and mining of beach sand, and by the interdiction of natural sediment processes by jetties, breakwaters, groynes, and piers. These structures accumulate sand and sediment, interfere with the transport of sand down the coast, and often initiate the construction of additional protective structures, which results in a permanent modification of shore zone processes. [2]

[1] D. Earl Jones, "Housing and Related Coastal Problems- Current Practices Offer Improved Solutions," Oct. 17,1977, convention paper.

[2] Douglas L. Inman and Birchard M. Brush, "The Coastal Challenge," *Science*, July 6, 1973. pp. 20-32.

The prospects for constructive responses to the erosion hazard would be improved if answers could be provided by research to questions such as the following:

- To **what extent is coastal erosion a hazard in itself, rather than a symptom, or effect of other coastal phenomena?**
- How **are short-term erosion fluctuations and long-term geophysical trends differentiated? Which policy options match short-term erosion fluctuations, and which options are feasible in the face of long-term trends?**
- What kinds of innovations in measurement can be expected soon? Can verification and measurement be reliable and unambiguous so that public expenditures can be justified and effectively allocated?
- What rights of intervention are available to public jurisdictions seeking to use setbacks and public acquisition of vulnerable coastal property?

Appendix B: Executive Order 11988

FLOODPLAIN MANAGEMENT

By virtue of the authority vested in me by the Constitution and statutes of the United States of America, and as President of the United States of America, in futherance of the National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321 et seq.), the National Flood Insurance Act of 1968, as amended (42 U.S.C. 4001 et seq.), and the Flood Disaster Protection Act of 1973 (Public Law 93-234, 87 Stat. 975), in order to avoid to the extent possible the long- and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct or indirect support of floodplain development whereever there is a practicable alternative, it is hereby ordered as follows:

Sec. 1. Each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out its responsibilities for (1) acquiring, managing, and disposing of Federal lands and facilities; (2) providing federally undertaken, financed, or assisted construction and improvements; and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities.

Sec. 2. In carrying out the activities described in section 1 of this Order, each agency has a responsibility to evaluate the potential effects of any actions it may take in a floodplain; to ensure that its planning programs and budget requests reflect consideration of flood hazards and floodplain management; to prescribe procedures to implement the policies and requirements of this Order, as follows:

(a)(2) Before taking an action, each agency shall determine whether the proposed action will occur in a floodplain-for major Federal actions significantly affecting the quality of the human environment, the evaluation required below will be included in any statement prepared under section 102(2)(C) of the **National Environmental Policy Act. This determination shall be made according to a Department of Housing and Urban Development (HUD) floodplain map or a more detailed map of an area, if available. If such maps are not available, the agency shall make a determination of the location of the floodplain based on the best available information. The Water Resources Council shall** issue guidance on this information not later than October 1, 1977.

(2) If an agency has determined to, or proposes to, conduct, support, or allow an action to be located in a floodplain, the agency shall consider alternatives to avoid adverse effects and incompatible development in the floodplains. If the head of the agency finds that the only practicable alternative consistent with the law and with the policy set forth in this Order requires siting in a floodplain, the agency shall, prior to taking action, (i) design or modify its action in order to minimize potential harm to or within the floodplain, consistent with regulations issued in accord with section 2(d) of this Order, and (ii) prepare and circulate a notice containing **an** explanation of why the action is proposed to be located in the floodplain.

(3) For programs subject to the Office of Management and Budget Circular A-95, the agency shall send the notice, not to exceed three pages in length including a location map, to the State and areawide A-95 clearinghouse for the geographic areas affected. The notice shall include: (i) the reasons why the action is proposed to be located in a floodplain; (ii) a statement indicating whether the action conforms to applicable State or local floodplain protection standards; and (iii) a list of the alternatives considered. Agencies shall endeavor to allow a brief comment period prior to taking any action.

(4) Each agency shall also provide opportunity for early public review of any plans or proposals for actions in floodplains, in accordance with section 2(b) of Executive Order No. 11514, as amended, including the development of procedures to accomplish this objective for Federal actions whose impact is not significant enough to require the preparation of an enviromnental impact statement under section 102(2)(C) of the National Environmental Policy Act of 1969, as amended.

(b) Any requests for new authorizations or appropriations transmitted to the Office of Management and Budget shall indicate, if an action to be proposed will be located in a floodplain, whether the proposed action is in accord with this Order.

(c) Each agency shall take floodplain management into **account** when formulating or evaluating any water and land use plans and shall require land and water resources use appropriate to the degree of hazard involved. Agencies shall include adequate provision for the evaluation and consideration of flood hazards in the regulations and operating procedures for the licenses, permits, loan or grants-in-aid programs that they administer. Agencies shall also encourage and provide appropriate guidance to applicants to evaluate the effects of their proposals in floodplains prior to submitting applications for Federal licenses, permits, loans or grants.

(d) As allowed by law, each agency shall issue or amend existing regulations and procedures within one year to comply with this Order. These procedures shall

incorporate the unified national program for floodplain management of the Water Resources Council, and shall explain the means that the agency will employ to pursue the nonhazardous use of riverine, coastal and other floodplains in connection with the activities under its authority. To the extent possible, existing processes, such as those of the Council on Environmental Quality and the Water Resources Council, shall be utilized to fulfill the requirements of this Order. Agencies shall prepare their procedures in consultation with the Water Resources Council, the Federal Insurance Administration, and the Council on Environmental Quality, and shall update such procedures as necessary.

Sec. 3. In addition to the requirements of section 2, agencies with responsibilities for Federal real property and facilities shall take the following measures:

(a) The regulations and procedures established under section 2(d) of this Order shall, at a minimum, require the construction of Federal structures and facilities to be in accordance with the standards and criteria and to be consistent with the intent of those promulgated under the National Flood Insurance Program. They shall deviate only to the extent that the standards of the Flood Insurance Program are demonstrably inappropriate for a given type of structure or facility.

(b) If, after compliance with the requirements of this Order, new construction of structures or facilities are to be located in a floodplain, accepted floodproofing and other flood protection measures shall be applied to new construction or rehabilitation. To achieve flood protection, agencies shall, wherever practicable, elevate structures above the base flood level rather than filling in land.

(c) If property used by the general public has suffered flood damage or is located in an identified flood hazard area, the responsible agency shall provide on structures, and other places where appropriate, conspicuous delineation of past and probable flood height in order to enhance public awareness of and knowledge about flood hazards.

(d) When property in floodplains is proposed for lease, easement, right-of-way, or disposal to non-Federal public or private parties, the Federal agency shall (1) reference in the conveyance those uses that are restricted under identified Federal, State or local floodplain regulations; and (2) attach other appropriate restrictions to the uses of properties by the grantee or purchaser and any successors, except where prohibited by law; or (3) withhold such properties from conveyance.

Sec. 4. In addition to any responsibilities under this Order and sections 202 and 205 of the Flood Disaster Protection Act of 1973, as amended (42 U.S.C. 4106 and 4128), agencies which guarantee, approve, regulate, or insure any financial transaction which is related to an area located in a floodplain shall, prior to completing action on such transaction, inform any private parties participating in the transaction of the hazards of locating structures in the floodplain.

Sec. 5. The head of each agency shall submit a report to the Council on Environmental Quality and to the Water Resources Council on June 30, 1978, regarding the status of their procedures and the impact of this Order on the agency's operations. Therafter, the Water Resources Council shall periodically evaluate agency procedures and their effectiveness.

Sec. 6. As used in this Order:

(a) The term "agency" shall have the same meaning as the term "executive agency" in section 105 of tide 5 of the United States Code and shall include the military departments; the directives contained in this Order, however, are meant to apply only to those agencies which perform the activities described in section 1 which are located in or affecting floodplains.

(b) The term "base flood" shall mean that flood which has a 1 percent or greater chance of occurrence in any given year.

(c) The term''floodplain" shall mean the lowland and relatively flat areas adjoining inland and coastal waters including floodprone areas of offshore islands, including at a minimum, that area subject to a one percent or greater chance of flooding in any given year.

Sec. 7. Executive Order No. 11296 of August 10, 1966, is hereby revoked. All actions, procedures, and issuances taken under that Order and stilI in effect shall remain in effect until modified by appropriate authority under the terms of this Order.

Sec. 8. Nothing in this Order shall apply to assistance provided for emergency work essential to save lives and protect property and public health and safety, performed pursuant to sections 305 and 306 of the Disaster Relief Act of 1974 (88 Stat. 148, 42 U.S.C. 5145 and 5146).

Sec. 9. To the extent the provisions of section 2(a) of this Order are applicable to projects covered by section 104(h) of the Housing and Community Development Act of 1974, as amended (88 Stat. 640, 42 U.S.C. 5304(h)), the responsibilities under those provisions may be assumed by the appropriate applicant, if the applicant has also assumed, with respect to such projects, all of the responsibilities for environmental review, decisionmaking, and action pursuant to the National Environmental Policy Act of 1969, as amended.

JIMMY CARTER

THE WHITE HOUSE
May 24, 1977.