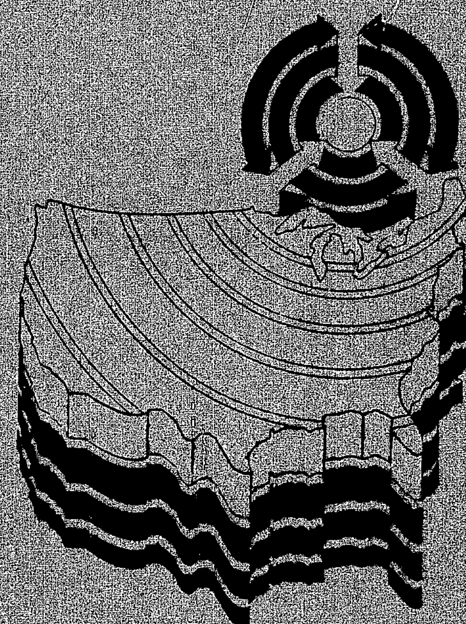
FLOODPLAIN MANAGEMENT
in the
UNITED STATES:
AN ASSESSMENT REPORT

VOLUME 2: FULL REPORT



PREPARED FOR
THE FEDERAL INTERAGENCY
FLOODPLAIN MANAGEMENT
TASK FORCE

FIA-18 / June 1992

1992

ISSUED IN FURTHERANCE OF THE
DECADE FOR NATURAL DISASTER REDUCTION

The Federal Interagency Floodplain Management Task Force was established in 1975 to carry out the responsibility of the President to prepare for the Congress a Unified National Program for Floodplain Management. Since 1982 the Task Force has been chaired by the Federal Emergency Management Agency. Membership of the Task Force consists of the Departments of Agriculture, Army, Commerce, Energy, Housing and Urban Development, Interior, and Transportation; the Environmental Protection Agency; Federal Emergency Management Agency; and the Tennessee Valley Authority.

FLOODPLAIN MANAGEMENT IN THE UNITED STATES: AN ASSESSMENT REPORT

VOLUME 2: FULL REPORT

Prepared For:

The Federal Interagency Floodplain Management Task Force

Prepared By:

L.R. Johnston Associates
(Contract No. TV-72105A)

1992

FOREWORD

Twenty-five years ago a report by the Bureau of the Budget to the President of the United States called for a "Unified National Program to Reduce Flood Losses." Much has happened since that recommendation was put forth in 1966. In 1991, *Floodplain Management in the United States: An Assessment Report* (the *Assessment Report*) measures the pulse of national efforts at floodplain management. The purpose of the *Assessment Report* is to document the progress that has been made and to identify new directions that may be pursued to reduce flood losses and protect floodplain natural values.

The term "floodplain management" has been a source of some confusion. The term has evolved over the years along with our experience and ideas for addressing the problems related to use and development of the Nation's riverine and coastal floodplains. During the 1930s to 1950s, floodplain management was typically defined in terms of flood control projects. This definition was tempered by recognition and acceptance of nonstructural approaches to flood problems during the 1960s. Then, in 1968, the National Flood Insurance Act directed the President to report to Congress on progress toward achieving a "Unified National Program for Floodplain Management" and suggested a much broader definition of floodplain management, a definition concerned with wise use of the Nation's floodplains. In more recent years, the importance of the natural resources and ecological functions associated with floodplains has become widely recognized, and the definition of floodplain management has been further expanded.

This evolution of thinking is today reflected in *A Unified National Program for Floodplain Management* (1986) prepared by the Federal Interagency Floodplain Management Task Force. Briefly stated, floodplain management is a decision-making process driven by the goal of achieving wise use of lands subject to flooding. "Wise use" is use compatible with: 1) the risk to human life and property posed by flooding; and 2) floodplain natural resource functions such as water quality functions and biological resource functions. Compatibility of floodplain use with risks to life and property is achieved through the three strategies of modifying susceptibility to flooding, modifying flood waters, and modifying the impact of flooding. Compatibility with natural resource functions is achieved through the two strategies of floodplain preservation and restoration. A variety of "tools" are used to accomplish each of these strategies.

This assessment of floodplain management in the United States has been prepared in response to recommendations contained in *A Unified National Program for Floodplain Management* (1986) which was transmitted by the Interagency Task Force to the President and the Congress. The *Assessment Report* provides a compilation of information concerning the nature of floodplains and experience with the various strategies and tools for managing floodplains. The report also provides an evaluation of the current status of floodplain management as seen by floodplain management experts.

Task Force member agencies have concurred with the content of this document, and believe that the assessment will serve as a benchmark against which future progress may be measured and as a platform on which to develop recommendations for improving the Nation's floodplain management efforts. These recommendations will be incorporated in the Task Force's 1992 update of *A Unified National Program for Floodplain Management.*

The Task Force recognizes that any assessment of a subject as complex and constantly evolving as floodplain management will never be truly complete and that some inaccuracies will occur in spite of diligent efforts to avoid them. We therefore welcome and encourage any comments, suggestions, and corrections pertaining to the information and conclusions contained in the *Assessment Report.*

Thanks are due to all who contributed information and ideas to the assessment. In particular, the Task Force wishes to acknowledge the principal contractor — the late Larry R. Johnston who passed away when the assessment was more than 95% completed. His driving commitment to "making a difference" in floodplain management and his unswerving dedication to the highest standards of professional quality are evident throughout the report.

Frank H. Thomas, Chair
Federal Interagency Floodplain Management Task Force
Federal Emergency Management Agency

PREFACE

In 1987, the Federal Interagency Floodplain Management Task Force commissioned an assessment of floodplain management in the United States. At that time, it was envisioned that the assessment could be completed in approximately two years. Hindsight now shows our originally proposed schedule to have been overly ambitious and unrealistic. Riverine and coastal floodplains are a large, diverse and dynamic part of our Nation. We did not, at the outset of our efforts, perceive the extent of difficulty that would be associated with obtaining, compiling and evaluating data from numerous sources in order to describe the various programs and activities that affect the Nation's floodplains. In addition, more time than originally anticipated was needed to actively seek and reflect the views of those having important knowledge of the effectiveness of floodplain management. The project was also beset by a personal tragedy, further delaying completion.

Now that the *Assessment Report* is finished, we can more fully appreciate the scale and complexity of any attempt to comprehensively assess floodplain management on the National level. Because of the evolving nature of floodplain management and the physical and other changes constantly being experienced in the Nation's floodplains, we can also appreciate the fact that no such effort at assessment can ever be considered as truly complete.

In carrying out the assessment, a preliminary report — *A Status Report on the Nation's Floodplain Management Activity: An Interim Report* — was first prepared to include a description of the Nation's floodplains and the measures being applied to reduce losses caused by flooding. An evaluation of the effectiveness of those measures was then carried out and the results of the two efforts were combined to provide the basis for the *Assessment Report*. An important goal of the overall assessment was to provide a balanced view of the implementation of all floodplain management measures and the activities of all governmental levels and the private sector.

The efforts of the many individuals, agencies and organizations that contributed to the assessment and to completion of the *Assessment Report* were exemplary. L.R. Johnston Associates (the contractor) was selected by the Task Force to conduct the assessment. The contractor's project team included Leslie A. Bond Associates, J.A. Kusler Associates, and the Association of State Floodplain Managers, Inc. A National Review Committee, consisting of recognized floodplain management experts, was established by the Task Force to assist in carrying out the assessment.

Larry R. Johnston, principal author of the *Assessment Report*, died in November of 1990 when his work was nearly complete. The Task Force contracted with his estate and with the Natural Hazards Research and Applications Information Center at the University of Colorado, Boulder, to assist in finishing the *Assessment Report*. Geoffrey Steadman and Jacquelyn Monday were employed, respectively, under those contracts. Gilbert White graciously consented to provide an invited comment. The Natural Hazards Center also prepared an Executive Summary.

Readers of the *Assessment Report* may identify several limitations of content and organization that are to be expected in any effort of such broad scope. There is, for example, some concern that on-going contributions to floodplain management by the nonfederal sector are not fully documented in the report. It is difficult to determine and describe all of the nonfederal efforts, particularly those that are independent of federal programs and policies. In some instances, information and aggregated data on the nonfederal contributions have not been previously compiled or readily available. Also, data pertaining to the effectiveness of floodplain management measures are typically incomplete and hence the difficulty in assessing, with certainty, the effectiveness of some measures.

The repetition of material between chapters may also be of concern to some readers. The report is designed to be a reference document and each chapter was written to stand by itself. We assume that readers will study and use the information in selected chapters according to interest and need.

The significance of the *Assessment Report* is apparent when one considers that prior to its issuance there had been no single comprehensive statement on the Nation's floodplain management activity since House Document 465, *A Unified National Program for Managing Flood Losses*, was issued in 1966. Thus, there was no comparative basis for evaluating over time the effectiveness of various tools, policies, and program planning efforts for floodplain management, and no comparative basis for justifying program budgets.

Funding for the assessment was provided by the following member agencies of the Federal Interagency Floodplain Management Task Force: Department of Agriculture; Department of the Army; Environmental Protection Agency; Federal Emergency Management Agency; Department of the Interior; and the Tennessee Valley Authority. Because of the TVA's long history of floodplain management experience, expertise and leadership, the Task Force requested that the TVA take the lead role in managing the interagency effort, including the contracting of professional services.

The *Assessment Report* could not have been completed were it not for the many efforts of an Advisory Committee of the Interagency Task Force. The members of the Advisory Committee secured agency support and funding, assisted in the collection of data from federal agencies, met on numerous occasions with the contractor (and later with others) to review progress and provide requested advice and direction, reviewed and commented on various draft documents, and provided for the review and input of others. Members of the Advisory Committee are:

Bruce Brown, Bureau of Reclamation
Billy Colson, U.S. Geological Survey
Wayne Graham, Bureau of Reclamation
Ross MacKay, Federal Emergency Management Agency
John Meagher, Environmental Protection Agency
Jeanne Melanson, Environmental Protection Agency
Jerry Peterson, U.S. Army Corps of Engineers
Larry Roberts, Bureau of Reclamation
Frank Thomas, Federal Emergency Management Agency
Don von Wolffradt, Soil Conservation Service
Jim Wright, Tennessee Valley Authority

This *Assessment Report* can be largely attributed to Larry R. Johnston, whose talents, energy and enthusiasm were well-suited for the required effort and who was instrumental in the conceptualization, preparation and completion of the work. We hope that the information and findings contained in the report will improve understanding of the current status of floodplain management and be of benefit to future efforts to advance the wise use and conservation of our Nation's floodplains. Comments are welcomed, particularly views on the completeness and accuracy of the assessment. Additional, more periodic reporting on progress toward implementation of a Unified National Program for Floodplain Management should be expected in the future.

James M. Wright
Project Manager
Tennessee Valley Authority

ACKNOWLEDGMENTS

Many individuals, agencies and organizations contributed to the preparation of this *Assessment Report.*

The Federal Interagency Floodplain Management Task Force provided funding for the work and the Advisory Group of the Task Force provided important guidance throughout the work effort. The Advisory Group assisted with organizing and conducting special conference workshops to gather information and sought input from a number of knowledgeable agencies and organizations. In addition, the Advisory Group established a National Review Committee to assist in preparing the Assessment Report. James M. Wright of the Tennessee Valley Authority served as Project Manager to coordinate the work efforts and provide overall direction and supervision of the assessment.

Thanks should be given to the members of the National Review Committee who reviewed *A Status Report on the Nation's Floodplain Management Activity: An Interim Report* (the *Status Report* — a preliminary report released in the course of work on the *Assessment Report*), and offered detailed comments on the data and analysis contained in the *Status Report.* On their own time the Committee met for several days to prepare an "Action Agenda for Managing the Nation's Floodplains." This Action Agenda is included as Appendix F of the *Assessment Report.* Members of the Review Committee are: Raymond J. Burby, Gerald E. Galloway, James E. Goddard, James G. Gosselink, H. James Owen, Rutherford H. Platt, William E. Riebsame (Vice Chair), John R. Sheaffer, French Wetmore, Gilbert F. White (Chair), and Stanley M. Williams.

Gilbert White, one of the pioneers of floodplain management whose 1942 dissertation first proposed a broad, integrated approach to solving the Nation's flood problems, prepared an "invited comment" and deserves special thanks for sharing his 50 years of experience and observations of floodplain activities.

Appreciation should also be extended to all of the other individuals, including those representing governmental agencies and professional and nonprofit organizations, who contributed to the report. Some of these individuals participated in the several conference workshops held to obtain information for the assessment, completed the questionnaires distributed at those workshops, and thereby provided important input for preparation of the *Assessment Report.* In this regard, thanks must be extended to the Association of State Floodplain Managers and the Association of Wetland Managers for arranging for special workshops to be held during their national conferences. All of the agencies, organizations and individuals who reviewed the *Status Report* and responded to requests for comments on the *Status Report* also provided important input. Those agencies, organizations and individuals are listed in Appendix E.

The primary contractor for preparation of the *Assessment Report* was L.R. Johnston Associates of Westport, Connecticut. Larry R. Johnston was the principal author of the report and, as L.R. Johnston Associates' Project Manager, coordinated the work of several subcontractors and assisted the National Review Committee. From L.R. Johnston Associates, Geoffrey Steadman, Julie Troy and Richard Backer also contributed to preparation of the report. Following Mr. Johnston's untimely passing in November of 1990, Mr. Steadman completed the work by editing the text and preparing the final report document.

Subcontractors to L.R. Johnston Associates were Leslie A. Bond Associates, J.A. Kusler Associates, and the Association of State Floodplain Managers, Inc. Les Bond contributed to those sections of the *Assessment Report* that address data collection for floodplain management, regional approaches to floodplain management, floodplain mapping, warning and preparedness measures, and structural flood protection efforts. Jon Kusler provided important advice and guidance, particularly with respect to court decisions and legal interpretations affecting floodplain management. The Association of State Floodplain Managers provided data on state and community floodplain management efforts.

The Natural Hazards Research and Applications Information Center at the University of Colorado, Boulder, under a separate contract with the Federal Interagency Floodplain Management Task Force, assisted in completing the final two chapters of the *Assessment Report* and prepared the *Summary Report*. The Natural Hazards Research and Applications Information Center subcontracted with Jacquelyn Monday to undertake this work. Ms. Monday was the principal author of chapters 15 and 16 of the *Assessment Report* and prepared the text of the *Summary Report*. The Executive Summary was prepared by David Butler of the Natural Hazards Center.

Dedication

This report is dedicated to the memory of Larry R. Johnston — friend, professional, and proponent of the wise use and conservation of our Nation's floodplains. From 1987 until his death in November of 1990, Larry worked closely with the Federal Interagency Floodplain Management Task Force to prepare the first national assessment of the status of floodplain management in the United States. His work was characterized by dedication to two guiding principles: he wanted his efforts "to make a difference" by having a beneficial effect on the lives of others; and his work was consistently marked by an unswerving pursuit of the highest quality.

Because of this dedication, the Assessment Report will be a bench mark document with respect to future floodplain management decisions in the United States. Through his depth of knowledge and broad understanding, Larry Johnston proved himself to be one of the few true floodplain management experts of our time. More importantly, he was able to achieve his goal of "making a difference" in the lives of others. His passing leaves us at great loss.

CONTENTS

PART IV: APPLICATION OF THE STRATEGIES AND TOOLS FOR FLOODPLAIN MANAGEMENT

PART V: APPROACHING THE NEXT CENTURY

PART VI: EPILOGUE

PART VII: APPENDICES

INDEX

LIST OF TABLES

LIST OF FIGURES

Page

FLOODPLAIN MANAGEMENT IN THE UNITED STATES: AN ASSESSMENT REPORT

EXECUTIVE SUMMARY

This assessment of floodplain management in the United States was commissioned by the Federal Interagency Floodplain Management Task Force — representatives of the Federal Emergency Management Agency; Departments of Agriculture, Army, Commerce, Energy, Housing and Urban Development, Interior, and Transportation; the Environmental Protection Agency; and the Tennessee Valley Authority — in order to report to the public and to the Congress on progress toward implementation of "A Unified National Program for Floodplain Management" [Section 1302(c) of the National Flood Insurance Act of 1968].

THE NATION'S FLOODPLAINS, THEIR VALUE, AND THEIR FLOODS

FLOODPLAINS

Estimates of the extent of the Nation's floodplains vary according to the areas measured. The U.S. Water Resources Council estimated in 1977 that they comprise about 7%, or 178.8 million acres, of the total area of the United States and its territories. A 1991 study by the Federal Emergency Management Agency that examined all mapped floodprone communities estimated there are about 93.8 million acres. This land includes areas next to rivers and streams, and the shores of oceans, lakes, and other bodies of water. Floodplains include many of the Nation's most beautiful landscapes, productive wetlands, fertile soils, and valuable natural habitat, as well as significant archaeologic and historic sites. Portions of almost all major cities and many smaller communities are located on or near floodplains.

THE VALUE OF FLOODPLAINS

In their natural state, floodplains have enormous value. They typically provide natural flood and erosion control, help maintain good water quality, and contribute to sustaining groundwater supplies for the Nation's water resources. Their wetlands and other unique riparian ecosystems provide a wide variety of fish and wildlife habitats and frequently support large and diverse populations of flora and fauna which are living, or biologic, resources. Additionally, they include many economic and cultural resources. They yield a harvest of natural and cultivated products; provide space for recreation, scientific study, and outdoor education; and encompass many sites of historic and archaeologic interest.

FLOODS

Riverine and coastal floodplains are, by definition, lands shaped by and continually subject to inundation. Riverine flooding — the most common type of flooding in the United States — can result not only from heavy rainfall and rapid snowmelt but also from dam or levee failure, ice jams, and channel migration. The resultant inundation can be relatively slow, or, in the case of flash flooding, devastatingly sudden. Coastal flooding and erosion can be caused by hurricanes, severe storms, tsunamis, or rising sea or lake levels. In addition, natural erosion can be accelerated by human development and poorly planned beach protection measures. Other floodprone areas include alluvial fans, urban areas where flooding is exacerbated by surface runoff and locally inadequate drainage, and areas affected by land subsidence and various forms of ground failure, such as mud floods, debris flows, and liquefaction.

Floodplain Losses

Today, the Nation includes nearly 22,000 floodprone communities. In recent years the annual growth rate in these areas, especially in coastal regions, has greatly exceeded that of the country as a whole. This large-scale development and modification of riverine and coastal floodplains has exacted a high price in damages due to floods.

The two main kinds of floodplain losses are loss of life and property and loss of natural and cultural resources. The actual and relative amounts of these losses are not well quantified, and the gathering of reliable, consistent data on injuries, deaths, damages, and the provision of aid remains a significant need in floodplain management. However, it is known that between 1916 and 1985 there were, on average, 101.4 flood-related deaths annually and that there is no indication that deaths are increasing or decreasing on a per capita basis. On the other hand, there definitely has been an increase in property damages over that 70-year period. Per capita flood damages were almost 2.5 times as great from 1951 to 1985 as from 1916 through 1950, after adjusting for inflation. Floods account for more losses than any other natural disaster in the United States (with the exception of some drought periods) and flood damages constitute the bulk of federal financial aid for disasters.

Less well quantified, but perhaps equally significant, is the loss of floodplain resources due to human use of the floodplain and subsequent degradation and flooding. All three types of floodplain resources — water, living, and cultural — are threatened by human activity in the floodplain. For example, widespread clearing and development can result in increased runoff, flooding, and erosion; waste disposal can degrade surface and groundwater; and drainage, alteration, and development can destroy natural wildlife habitat and the aesthetic and recreational attributes of floodplains and wetlands.

MANAGING FLOODPLAINS TO REDUCE LOSSES

The History of Floodplain Management

Before 1965, government acted to reduce floodplain losses primarily in response to major disasters, and most of these efforts involved structural measures (channelization, the construction of dams, levees, etc.). During the mid-1960s, federal policy began to broaden to include nonstructural means, and the last 25 years have witnessed a major expansion in floodplain management practices that incorporates better ways for analyzing and predicting flooding, recognizes the importance of the natural resources of floodplains, and adjusts the responsibilities of federal, state, and local governments and the private sector. Zoning and other land use regulation, flood forecasting, federal flood insurance, alternative stormwater management techniques, and relocation of property have all become significant floodplain management tools.

The Management Framework

Floodplain management is carried out within a structure of legislative, administrative, economic, and judicial opportunities, incentives, and constraints that is tempered by public interest and the availability of needed information. The Unified National Program for Floodplain Management establishes as a basic national goal the wise use of floodplains; sets forth the conceptual framework of a multi-objective approach to use of the Nation's floodplains, including flood loss reduction and natural resource protection; identifies implementing strategies and tools; and recognizes the respective roles of each level of government and the private sector.

There are four main strategies for reducing floodplain losses, each of which is carried out by using one or more specified "tools" — activities undertaken by governments, individuals, or the private sector that have an impact on floodplain management:

1. *Modifying susceptibility to flood damage and disruption — the floodplain management strategy of avoiding dangerous, uneconomic, undesirable, or unwise use of the floodplain.* The tools used to implement this strategy are regulations; development and redevelopment policies; disaster preparedness; floodproofing

and elevation; and flood forecasting, warning systems, and emergency plans. This strategy has enjoyed widespread, fairly successful implementation.

2. *Modifying flooding — the floodplain management strategy of using structural means to alter the flood itself.* Structural measures include dams, reservoirs, dikes, levees, floodwalls, channel alterations, high flow diversions, spillways, land treatment measures, shoreline protection works, and stormwater management facilities. Although flood control projects have prevented much damage and suffering, the number and size of structural projects have been decreasing in recent years. High construction costs, increased cost-sharing requirements, increased recognition of environmental consequences, and greater understanding of the long-term costs and consequences of these measures have all deterred new construction of large structures. However, local and private construction of smaller flood control projects is certain to continue and may even increase.

3. *Modifying the impacts of flooding on individuals and the community — the floodplain management strategy of helping individuals and communities prepare for and recover from floods.* The tools used to implement this strategy include information dissemination and education, spreading the costs of the loss over time and among those at risk, and transferring some individual losses to the community. Although there has been great improvement in recent years in many aspects of the present combination of public education, flood insurance, disaster assistance, tax adjustments, and postflood recovery practices, the overall effectiveness and equity of these efforts are not clear.

4. *Restoring and preserving the natural and cultural resources of floodplains — the floodplain management strategy of protecting the water, living, and cultural resources of floodplains.* The best way to guard these resources is to avoid development within floodplains. Limited preservation and restoration can also be accomplished indirectly through other flood loss reduction activities or natural resources management programs. The latter, however, typically do not focus on floodplains but instead address a particular resource throughout its natural range. Because these approaches may have limited relevance to floodplain management, some local jurisdictions have moved toward programs to combine other community objectives with floodplain management. These multi-objective programs typically take two forms: greenway or river corridor projects and community redevelopment projects.

THE EFFECTIVENESS OF FLOODPLAIN MANAGEMENT

Perception and Awareness of Floodplain Losses

Substantial progress has been made in increasing institutional awareness of the flood risk. However individual awareness is generally inadequate, resulting in unwise development of flood hazard areas and disregard for the value of natural floodplains. Local perception of flood hazards — by both governments and floodplain residents — is related to previous experience with flooding; the extent to which the floodplain is developed; the existence of structural control measures; the seriousness of flooding in relation to other community problems; and attitudes about land use, water resources management, and regulations. In general, the threat of damage from coastal flooding seems to be taken more seriously by communities than is damage from riverine flooding.

The protection of the natural and cultural resources of floodplains is becoming a popularly expressed environmental objective and represents a potentially broad base of public support for floodplain management. Informing and educating the public about both flood risk and the importance of the natural and cultural resources of floodplains remains an ongoing effort requiring ingenuity and persistence.

Knowledge, Standards, and Technology

Effective floodplain management requires a sound understanding of the physical, biological, and chemical processes that affect flood hazards and the natural resources of floodplains, and an appreciation of the social processes involved in human interaction with them. Additionally, the institutions and individuals that deal with floodplain problems must have a broad base of information, a range of technologies to deal with emerging problems, and standards to which they can refer for guidance. Research in both the public and private sectors has enhanced our knowledge and provided new and better tools in all of these areas.

Judicial Support for Floodplain Management

Over the last few decades the types of lawsuits and the specific issues litigated in floodplain management have changed, reflecting the predominant floodplain management techniques of the time and the general status of the relevant law. Today, although courts continue to hold governments liable for actions that increase flood damages, the number of constitutional challenges to regulations has diminished, due to continuing, widespread judicial support for regulation. Clearly, performance-oriented floodplain regulations (building codes, subdivision regulations, etc.) will continue to be upheld in the courts despite restrictions that may affect private property owners in some instances. Likewise, carefully crafted flood loss reduction measures will reduce community and state liability in the long run.

The Present and the Future

Regarding the effectiveness of floodplain management in the United States, there is general agreement on three goals and the Nation's success in meeting them:

1. *Floodplain management should reduce the number of flood-related deaths in the Nation.* This goal has been partially achieved. Average annual loss of life from flooding has been somewhat reduced from the level that prevailed early in this century and has remained relatively constant for many years.

2. *Floodplain management should result in an actual decline in the Nation's overall flood losses.* This has not been achieved. In fact, there was a definite increase in flood damages from 1916 to 1985, although there is evidence that these losses have remained fairly constant over the last two decades when compared to broad economic indicators like the GNP.

3. *Floodplain management should reduce the loss of the natural and cultural resources of the Nation's floodplains.* The programs designed to achieve this goal have not yet arrested that deterioration.

The difficulty in evaluating current floodplain management efforts underscores two critical needs for improving the Nation's floodplain management program. First, floodplain management would greatly benefit from a clear definition of its function and a set of measurable goals meant to be achieved by a certain date. Second, floodplain management would also benefit from a comprehensive data base of information on management activities. There is considerable information available about floodplain management, but most of it is not sufficiently precise to support judgments about the effectiveness of various floodplain management activities. Some specific areas that merit analysis include the full benefits and costs — both public and private — of floodplain occupancy, the monetary benefits of maintaining the natural uses of a floodplain, and the steps needed to reduce potential losses in the areas of the Nation with the highest risk of catastrophic flooding.

CONCLUSIONS

Although a truly unified national program to manage floodplains is not yet in place, great strides have been made in that direction. For example, awareness of flood hazards — particularly among public officials — has clearly increased, while loss of life and injury due to flooding has been curtailed. Nationwide mapping of floodprone areas by the Federal Insurance Administration has resulted in the initial mapping of more than 12,000 communities and the restudy of over 1,700 communities since coordinated studies began in the 1960s. Eighty-two percent of all floodprone communities in the United States have joined the National Flood

Insurance Program. On the technical side, computers are increasingly being incorporated into floodplain management and now facilitate such functions as hydrologic modeling, flood warning, and floodplain mapping.

These achievements notwithstanding, additional accomplishments could be realized through better, more extensive, and more flexible use of the strategies and tools of floodplain management. Of the four strategies, modifying flooding has traditionally been the most popular because most of the planning, funding, construction, and implementation for structural measures is carried out by the state or federal government, and because local and individual adjustments or sacrifices are minimal. Although there is increased recognition of possible adverse effects of these approaches, they are clearly still needed, particularly to protect existing development.

In comparison to structural approaches, many measures to modify susceptibility to flood damages or to modify the impacts of flooding are implemented on a property-by-property basis. With its increasing acceptance, modifying susceptibility to flooding may have the most potential for widespread future use, because its tools can be coordinated with other strategies and because it provides an ongoing, more enduring way of adjusting to the flood hazard — that is, altering human behavior usually before losses occur.

In contrast, the strategy of restoring and preserving the natural and cultural resources of floodplains has had little exposure to date and needs to be better integrated both with other floodplain management tools and strategies and with efforts in other fields, such as river corridor management and pollution control.

Looking ahead, further integration of these individual strategies and tools is inevitable, and, combined with technological advances that promise to improve their application, a more unified floodplain management program will certainly emerge, with fewer conflicts among goals and activities. Again, however, if we are to develop a truly Unified National Program for Floodplain Management, several actions must be pursued. Two appear particularly necessary: the concept of floodplain management must be well defined with specific national goals and timetables; and the base of information on floodplain management must be compiled in a more usable form.

INTRODUCTION

...Rivers were here long before man, and for untold ages every stream has periodically exercised its right to expand when carrying more than normal flow. Man's error has not been the neglect of flood-control measures but his refusal to recognize the right of the rivers to their flood-way...

Engineering News-Record, 1937

ASSESSMENT OF THE NATION'S PROGRAM[1] FOR FLOODPLAIN MANAGEMENT[2]

In 1987, the Federal Interagency Floodplain Management Task Force (the Task Force) initiated an "Assessment of Floodplain Management in the United States." The Assessment was commissioned to advance an earlier recommendation of the Task Force to "provide evaluation of floodplain management activities with periodic reporting to the public and to the Congress on progress toward implementation of a 'Unified National Program for Floodplain Management'." This recommendation was presented in the Task Force's 1986 report entitled *A Unified National Program for Floodplain Management.* The Assessment is particularly significant given the lack of comprehensive statements, examination, or assessment of the Nation's floodplain and flood hazard management activities since the landmark report *A Unified National Program for Managing Flood Losses* was published in 1976. The Assessment, which has provided an initial evaluation and report, establishes a basis for the Task Force to consider changes that may be needed to update and revise its 1986 report.

The Assessment is presented in three separate documents:

1) *Floodplain Management in the United States: An Assessment Report* (Volume 2: Full Report). This full report (the *Assessment Report*) describes in detail the evolution of current floodplain management activities and use of the several strategies and tools recognized as available for managing the Nation's floodplains and reducing flood losses. This document also provides an assessment of the effectiveness of the individual tools and of the Nation's overall program for floodplain management.

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1 Based on available data, information and program status as of the end of 1990.

2 "Floodplain management" is a decision-making process whose goal is to achieve wise use of the Nation's floodplains. "Wise use" is any activity or set of activities that is compatible with the risk to natural resources (natural and beneficial functions of floodplains) and human resources (life and property). Compatibility is achieved through the strategies and tools of the Unified National Program for Floodplain Management.

2) *Floodplain Management in the United States: An Assessment Report* (Volume 1: Summary Report). This separate and shorter report summarizes the information presented in the *Assessment Report.*

3) An *Executive Summary.* (Also included in Volume 2.)

DEVELOPMENT OF THE ASSESSMENT REPORT

In preparing this *Assessment Report*, the authors relied heavily on the professional judgments and sometimes divergent views of many individuals and groups actively involved with or affected by floodplain management activities. The *Assessment Report* evolved from *A Status Report on the Nation's Floodplain Management Activity: An Interim Report* (the *Status Report*), prepared by L.R. Johnston Associates for the Task Force in April of 1989. The major sources of information used to prepare the *Assessment Report* were:

- Comments provided by numerous government agencies, private organizations, and individuals who reviewed the *Interim Status Report* and responded to a questionnaire regarding the effectiveness of floodplain management;
- Comments by a committee (National Review Committee) of prominent floodplain and natural resource management professionals assembled for the specific purpose of assisting the Task Force in evaluating the effectiveness of floodplain management. (Appendix F contains the Committee's final report entitled "Action Agenda for Managing the Nation's Floodplains");
- Responses to a 1987-88 survey by the Association of State Floodplain Managers of state floodplain management activities.
- Responses from participants in a group of workshops held during the Association of State Floodplain Managers' national conference in June 1988 and responses from questionnaires distributed at this and two other national conferences during 1988;
- Published literature; and
- Comments from knowledgeable individuals concerned with floodplain management.

COMMENTS FROM GOVERNMENT AGENCIES AND PROFESSIONAL AND NONPROFIT ORGANIZATIONS

In 1989, the Task Force sent a questionnaire to a number of government agencies and professional and nonprofit organizations.[3] These questionnaires were designed to obtain observations on the effectiveness of present floodplain management activities and possible actions to improve future activities, as well as comments on the *Status Report.* Many reviewers responded with valuable, detailed comments; some also provided useful supplemental materials. All of the comments and materials received were carefully evaluated and incorporated into the Assessment to the extent feasible.

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3 A list of the government agencies and professional and nonprofit organizations that were contacted, along with a copy of the letter and questionnaire sent to each, is included in Appendix E.

COMMENTS FROM THE NATIONAL REVIEW COMMITTEE

A National Review Committee consisting of prominent floodplain and natural resource management professionals was formed by the Federal Interagency Floodplain Management Task Force in 1989. Chaired by Gilbert F. White, the Committee consisted of: Raymond J. Burby, Gerald E. Galloway, James E. Goddard, James G. Gosselink, H. James Owen, Rutherford H. Platt, William E. Riebsame (Vice Chair), John R. Sheaffer, French Wetmore, and Stanley M. Williams. The Review Committee reviewed the *Status Report* and provided detailed comments on the data and analysis contained in that report. Members of the Committee also prepared preliminary papers addressing the effectiveness of floodplain management and conducted two day-long meetings to review those papers. James M. Wright and Frank Thomas from the Task Force and Larry Johnston of L.R. Johnston Associates were observers at those meetings which led to formulation of the Committee's "Action Agenda for Managing the Nation's Floodplains" (the Action Agenda).

The Action Agenda report, which is included in its entirety in Appendix F, contains the Review Committee's observations on the present floodplain management situation, the evolution of the national floodplain management goals, and some key factors that affect the ability of government agencies and the private sector to improve floodplain management capabilities. The report ends with the Committee's recommendations for further actions that should be carried out by federal agencies to improve the current status of floodplain management.

The Action Agenda, along with the Committee's comments on the *Status Report*, has been incorporated into the *Assessment Report*. In formulating its Action Agenda, the Review Committee chose to make use of "professional judgments as to what has been happening and as to what accounts for conspicuous successes and failures" with regard to floodplain management.

INPUT FROM WORKSHOPS AND THE QUESTIONNAIRE ON FLOODPLAIN MANAGEMENT EFFECTIVENESS

Ten workshops designed to contribute to development of the *Assessment Report* were conducted at the Association of State Floodplain Managers' national conference in Nashville, Tennessee in May 1988. These workshops focused on different aspects of floodplain management. Questionnaires were distributed to workshop participants and the proceedings recorded. In addition, a special workshop was held during the Association of State Wetlands Managers' Oakland, California conference in June 1988. A questionnaire on the effectiveness of the Nation's floodplain management program was also distributed to participants at this workshop. Finally, a questionnaire was distributed to participants at the Natural Hazards Workshop held in Boulder, Colorado in July 1988.

INFORMATION FROM REVIEW OF AVAILABLE LITERATURE

Floodplain management literature of the past several years was reviewed. Most published reports in the field of floodplain management provide "how-to" information on some aspect of floodplain management, including documentation of successful programs and activities. There is a relatively small body of literature that actually evaluates the effectiveness of some aspect of floodplain management.

COMMENTS FROM INDIVIDUALS

During the course of work on the Assessment, discussions were held with scores of individuals regarding the status and effectiveness of floodplain management. Selected comments from these individuals provide useful insights supplemental to those from other sources and are included in the *Assessment Report.*

CONTENTS OF THE ASSESSMENT REPORT

As noted previously, the National Review Committee made use of professional judgments in its assessment of the effectiveness of floodplain management. A similar approach with regard to the use of professional judgment has been followed throughout the *Assessment Report.* Verifiable, nationwide data on floodplains and floodplain management suitable for determining program effectiveness is often lacking. As a result, the professional views, judgments and experience of many knowledgeable individuals and groups are particularly important in evaluating the effectiveness of the Nation's floodplain management activity and form the basis of much of the evaluation presented in the *Assessment Report.* It must be noted, however, that in many instances professional views and judgments vary considerably with regard to the effectiveness (or lack of effectiveness) of a particular aspect of floodplain management. There are also diverging opinions with regard to how effectiveness can be improved.

The *Assessment Report* presents available data in order to allow evaluation of the professional views and judgments offered. In some instances, anecdotal evidence based on professional experience is also included. Many of the opinions and judgments offered by those who have contributed to the *Assessment Report*, as well as opinions and judgments found in current literature, appear to be based on such evidence. Anecdotal examples are identified in the text by indented text in *italics*.

The *Assessment Report* is comprised of 16 chapters organized into five parts, plus the Part VI Epilogue, and several appendices.

- **PART I: THE NATION'S FLOODPLAINS.** Part I describes the different types of floods and floodplains in the United States and the many natural and cultural resources associated with floodplains. Flooding associated with natural phenomena such as ice jams, fluctuating lake levels, unstable channels, alluvial fans, ground failure, and surface runoff are covered, in addition to more well known riverine and coastal flooding.

- **PART II: THE NATION'S PROGRAM FOR FLOODPLAIN MANAGEMENT.** The two chapters that comprise Part II describe the gradual evolution of early initiatives for flood control into a national program for reducing flood losses and managing the natural and cultural resources of floodplains. These chapters provide a brief historical overview, describing how management efforts have shifted from the early emphasis on controlling floods with structural measures during most of this century, to the current approach involving a mix of both structural and nonstructural measures and including the protection and restoration of floodplain natural and cultural resources.

Part II also describes two important documents that have largely established the framework for floodplain management over the last 25 years:

- House Document 465, *A Unified National Program for Managing Flood Losses*, was prepared by the Task Force on Federal Flood Control Policy and submitted by President Johnson to Congress in 1966. This document established the foundation of a coordinated national effort to manage the Nation's floodplains.

- *A Unified National Program for Floodplain Management* was initially prepared by the U.S. Water Resources Council in 1976 in response to a directive in the 1968 National Flood Insurance Act. The document was revised and updated by the Water Resources Council in 1979 and by the Federal Emergency Management Agency in 1986. This document provides the conceptual framework for a Unified National Program for Floodplain Management.

- **PART III: CHANGES IN FLOODPLAIN MANAGEMENT SINCE THE 1960s:** Part III describes many of the changes that have taken place with regard to floodplain management since the mid-1960s when the concept of a Unified National Program was first established. These changes include: technological developments; improved understanding of basic concepts and development of new analytical procedures; changes in the institutional framework for floodplain management, including an expanded legislative base and the creation of new agencies; court decisions and interpretations; and increased institutional and individual perception and awareness of flood hazards and floodplain resources. Particularly noteworthy are the greater and more widespread recognition of the natural resources of floodplains that has developed over the last 25 years and the development of many new programs and initiatives at all levels of government (even though many of these programs tend to be single purpose programs that are not always well coordinated with one another). Also of significance is the shift away from federal dominance toward a more equal partnership among federal, state and local governments.

- **PART IV: APPLICATION OF THE STRATEGIES AND TOOLS FOR FLOODPLAIN MANAGEMENT:** Part IV examines how and to what extent each of the strategies and tools identified in *A Unified National Program for Floodplain Management* are currently being applied. The four basic strategies of floodplain management are:

  - Modifying Susceptibility to Flood Damages and Disruption
  - Modifying Flooding
  - Modifying the Impacts of Flooding
  - Managing Natural and Cultural Resources

- **PART V: APPROACHING THE NEXT CENTURY:** Part V of the *Assessment Report* addresses the extent to which the conceptual framework, the strategies and tools, and the specific recommendations set forth in *A Unified National Program for Floodplain Management* have been accomplished. It reviews the principal impediments to more effective floodplain management, current initiatives to address those impediments, and opportunities that have been suggested for increasing the effectiveness of floodplain management.

- **PART VI: EPILOGUE:** The Epilogue presents a closing comment by Gilbert F. White, one of the pioneers of floodplain management.

The *Assessment Report* does not contain specific recommendations for changes in the Nation's floodplain management program. Instead, the report provides information on the effectiveness of the current program for floodplain management, and presents various options that may be available for improving program effectiveness. The findings contained in the *Assessment Report* will be used by the Federal Interagency Floodplain Management Task Force as a basis for updating and revising its 1986 report *A Unified National Program for Floodplain Management*, and by specific agencies considering needed changes in their floodplain management programs.

PART I:

THE NATION'S FLOODPLAINS

The first part of the *Assessment Report* describes the different types of floods and floodplains in the United States and the many natural and cultural resources associated with floodplains. Flooding caused by natural phenomena such as ice jams, fluctuating lake levels, unstable channels, alluvial fans, ground failure, and surface runoff are described, in addition to more well known riverine and coastal flooding.

The three chapters in Part I provide an indication of what is known and not known about floods, floodplains, and their natural and cultural resources. Some of the limitations of present knowledge about floodplains include uncertainties over the total area of floodplain land in the United States, how much of this land is developed, the annual loss of life and property due to flooding, and the extent of historical or current losses of natural resources, particularly those values associated with wetlands and riparian habitat.

Recognition and understanding of the different types of floods and floodplains and the pressures for their development are essential to understanding the nature and evolution of the Nation's program for floodplain management. That program is described in subsequent parts of the *Assessment Report*.

CHAPTER 1:

FLOODS AND FLOODPLAINS

Floods are as much a part of the phenomena of the landscape as are hills and valleys; they are natural features to be lived with, features which require certain adjustments on our part.

Floods, Hoyt and Langbein, 1955

Floods are natural events that have always been an integral part of the geologic history of the country, helping to shape the landscape, providing habitat for wildlife, and creating rich agricultural lands. The physical diversity of the United States, in terms of climatic zones and geomorphic, hydrometeorologic and other factors, gives rise to a broad range of riverine, coastal and lacustrine (lake) flood situations. Although flooding is common in all 50 states, the type and frequency of flooding vary considerably from state to state and geographically within each state.[1]

Flooding occurs along major rivers and small streams, in coastal areas, and along the margins of some lakes. Other floodprone areas include alluvial fans and other types of unstable and meandering channels, ground failure areas, and areas influenced by structural measures. Riverine flood problems can develop from dam and levee failure, ice jams and channel migration as well as from heavy rainfall and rapid snowmelt. Coastal flooding can be caused by hurricanes, winter storms, tsunamis and rising sea levels. Individual storms and long-term climate variations are among the causes of lacustrine flooding. In addition, flooding due to surface runoff and locally inadequate drainage can be a major problem, particularly in rapidly urbanizing areas.

Human settlements and activities tend to use floodplains, frequently interfering with the natural floodplain processes and suffering inconvenience or catastrophe as a consequence. As human activities encroach upon floodplains and affect the distribution and timing of drainage, flood problems typically increase. The built environment also creates localized flooding problems outside of natural floodplains. Development often requires that runoff be controlled and confined in open or enclosed channels. Particularly in rapidly urbanizing areas, these drainage systems often have proven inadequate to control this runoff.

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1 This *Assessment Report* primarily reflects conditions and data in the 50 states. In many instances, sources of information used did not include data for Alaska or Hawaii. Where possible, data are also included for the District of Columbia, Commonwealth of Puerto Rico, and the U.S. territories and possessions (U.S. Virgin Islands, Guam and Northern Marianas). Information pertaining to conditions in Puerto Rico and the Virgin Islands is commonly classified as Caribbean area data.

Floodplains may be defined and identified in several ways. From a geological perspective, floodplains may include large areas of the landscape identified by natural terraces and other geologic features or by the presence of alluvial soils. A more restrictive definition of floodplains might include only the area adjacent to a stream or river that is being actively shaped by the forces of water (i.e., being eroded or built-up through sediment deposition). Another approach is to define the floodplain based on areas that were flooded during recorded historical flood events. Finally, the floodplain may be defined based on an estimate of the area required to carry the runoff resulting from precipitation of a particular magnitude (in terms of intensity and duration) and frequency.

For most management purposes in the United States today, floodplains are defined as the low lands adjoining the channel of a river, stream or watercourse, or adjoining the shore of an ocean, lake or other body of standing water, which have been or may be inundated by flood water. Floodplains are further categorized by the frequency of flooding, a general standard of which is the flood with a one percent chance of being equaled or exceeded in any given year — commonly known as the "100-year" flood or one percent flood. Floods, of course, are not confined to the area inundated by the one percent flood. Larger floods may occur, but since the 1960s the one percent flood has been generally accepted as a standard for most regulatory purposes.[2]

AREA SUBJECT TO FLOODING IN THE UNITED STATES

Because of the different ways in which floodplains may be defined and identified, there is no "official" estimate of the total United States land area that is subject to flooding. Several estimates of the amount of floodprone or floodplain land have been made, but none of these estimates have been truly comprehensive and they cannot be readily compared. A review of several of the best known and most comprehensive estimates of floodprone area reveals the great uncertainty that exists in attempting to determine the total area of the United States that is subject to flooding.

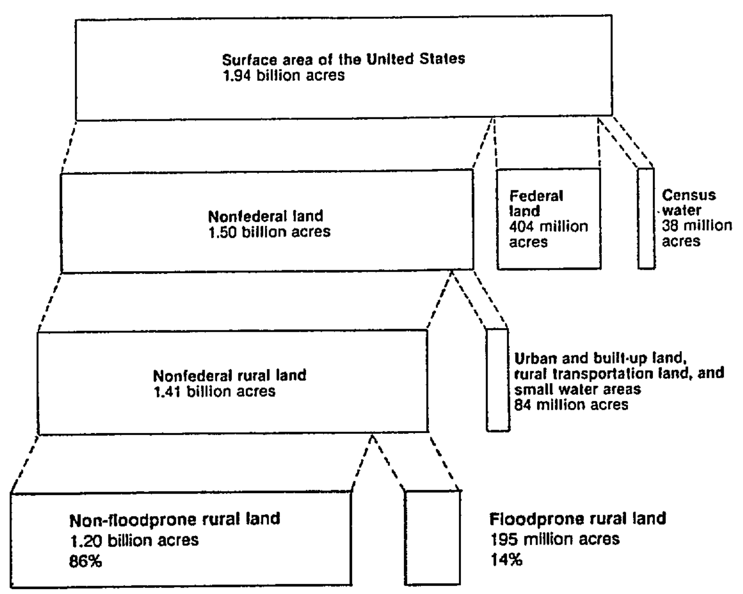
In the early 1940s at least 35 million acres of land in the United States (less than 2 percent of the total land area of the 48 states) were reported to be subject to flooding, although no attempt had then been made to inventory all vulnerable land (White, 1945). In 1976, it was estimated that 16 percent of the land in urban areas was within the one percent floodplain (Goddard, 1976). More comprehensive estimates of land subject to a one percent flood have been made by the U.S. Water Resources Council (WRC) in 1977, the Soil Conservation Service (SCS) in 1977, 1982 and 1987, and the Federal Emergency Management Agency (FEMA) in 1991.

- In 1977 the WRC estimated that about seven percent, or 178.8 million acres, of the area of the United States (including Alaska, Hawaii and the Caribbean) was within the one percent floodplain (U.S. Water Resources Council, 1977).

[2] See Chapter 8 for a more detailed description of the one percent flood as a regulatory standard.

- As part of the 1977 National Resources Inventory (NRI), the SCS estimated that approximately 175 million acres of rural, nonfederal land (excluding Alaska) were floodprone, based on data compiled in the early 1970s (Soil Conservation Service, 1982).

- In 1982, the SCS updated the NRI[3] and estimated that approximately 195 million acres (14%) of the nonfederal rural land of the country were floodprone. This represents 10% of the total surface area of the U.S. excluding Alaska, but including the Caribbean. Figure 1-1 illustrates how the nonfederal rural land relates to total surface area of the United States. Table 1-1 shows the breakdown of floodprone lands by state according to the 1982 NRI. States having the largest acreage of floodprone areas are Texas (20 million acres), Florida (14 million acres) and Louisiana (11 million acres) (Soil Conservation Service, 1984). Since portions of the urban and built-up land are known to be in the floodplain, but have not been quantified, the best that can be said is that somewhat more than 14% of total nonfederal land (excluding Alaska) is within the one percent floodplain.



Source: Soil Conservation Service, USDA. Basic Statistics, 1982 National Resource Inventory. Iowa State University Statistical Laboratory, Statistical Bulletin No. 756. 1987. Modified by L.R. Johnston Associates, 1990.

Figure 1-1. Surface Area of the United States and Floodprone Nonfederal Land, 1982.

- In the refinement of a 1987 study, FEMA estimated a total of 93.8 million acres of floodplain land based on an examination of nearly 17,500 mapped floodprone communities in the 50 states and the District of Columbia (Donnelley, 1987). As shown in Table 1-2, Texas, Louisiana and Florida have the largest floodplain areas, although the numbers differ somewhat from the NRI estimates.

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3 The SCS is conducting the NRI every five years. A new survey was initiated in 1987, but data from this latest survey are not yet available.

Table 1-1. Soil Conservation Service Estimate of Nonfederal, Rural Floodprone Areas (in Acres), by State, 1982.

STATE*	CROP-LAND	PASTURE-LAND	RANGE-LAND	FOREST-LAND	MINOR LAND COVER/USES	TOTAL
* Does not include Alaska.	thousands of acres					
Alabama	779.3	744.6	0.0	4,098.0	108.2	5,730.1
Arizona	88.7	26.0	2,437.0	10.3	249.1	2,811.1
Arkansas	3,027.1	818.1	4.9	2,948.8	89.2	6,888.1
California	3,386.6	599.6	1,872.2	224.5	970.1	7,053.0
Colorado	864.7	383.7	2,209.2	112.2	122.8	3,692.6
Connecticut	14.6	6.0	0.0	57.7	27.4	105.7
Delaware	0.0	1.2	0.0	31.9	96.2	129.3
Florida	1,286.7	1,797.2	2,482.3	5,582.8	3,034.5	14,165.5
Georgia	298.2	378.0	0.0	6,558.9	445.7	7,680.8
Hawaii	50.3	23.7	0.0	60.5	30.2	164.7
Idaho	658.3	484.1	282.1	125.2	122.5	1,672.2
Illinois	3,129.0	591.2	0.0	842.7	70.7	4,633.6
Indiana	1,591.4	264.3	0.0	497.4	103.9	2,457.0
Iowa	3,450.3	895.8	0.0	394.2	145.6	4,885.9
Kansas	3,570.5	277.3	1,866.1	333.3	157.4	6,204.6
Kentucky	1,684.1	659.4	0.0	598.3	90.3	3,032.1
Louisiana	2,459.5	608.8	227.5	5,210.5	2,983.9	11,490.2
Maine	60.8	14.5	0.0	816.9	275.3	1,167.5
Maryland	53.5	69.2	0.0	284.4	223.6	630.7
Massachusetts	21.0	15.6	0.0	108.5	107.3	252.4
Michigan	172.8	105.2	0.0	685.5	418.7	1,382.2
Minnesota	1,579.4	456.6	79.5	559.5	478.4	3,153.4
Mississippi	4,390.6	836.4	0.0	4,232.2	106.1	9,565.3
Missouri	5,138.9	1,674.6	21.9	1,109.2	128.5	8,073.1
Montana	945.3	575.3	1,988.2	211.1	237.8	3,957.7
Nebraska	3,298.2	437.7	2,191.4	310.2	180.5	6,418.0
Nevada	417.7	222.7	1,114.2	3.8	104.9	1,863.3
New Hampshire	24.7	12.4	0.0	68.7	49.9	155.7
New Jersey	40.3	36.4	0.0	322.5	268.1	667.3
New Mexico	217.2	48.0	3,530.3	65.6	135.3	3,996.4
New York	381.8	363.2	0.0	941.0	276.7	1,962.7
North Carolina	1,043.9	247.4	0.0	4,197.4	295.2	5,783.9
North Dakota	1,143.7	127.6	986.3	150.9	112.6	2,521.1
Ohio	907.1	275.2	0.0	504.7	158.5	1,845.5
Oklahoma	2,086.7	1,485.2	1,579.0	833.0	56.1	6,040.0
Oregon	855.7	770.5	596.9	182.6	205.3	2,611.0
Pennsylvania	295.5	285.8	0.0	707.9	133.2	1,422.4
Rhode Island	1.0	1.5	0.0	34.6	15.4	52.5
South Carolina	98.2	76.1	0.0	2,211.7	495.5	2,881.5
South Dakota	2,439.1	433.1	2,105.2	122.5	134.8	5,234.7
Tennessee	1,957.0	843.5	0.0	1,128.1	90.9	4,019.5
Texas	3,162.2	3,604.9	10,341.7	2,296.4	642.6	20,047.8
Utah	327.2	217.8	963.0	64.5	822.1	2,394.6
Vermont	70.2	44.8	0.0	79.2	26.7	220.9
Virginia	342.1	335.2	0.0	1,355.1	281.5	2,313.9
Washington	578.2	369.8	107.6	361.6	171.9	1,589.1
West Virginia	317.3	162.1	0.0	198.0	24.9	702.3
Wisconsin	1,555.6	741.3	0.0	2,144.7	1,502.9	5,944.5
Wyoming	405.2	185.8	2,125.5	39.5	70.5	2,826.5
Caribbean	115.4	124.4	0.0	6.8	39.3	285.9
TOTAL	60,764.8	23,758.8	39,112.0	54,025.5	17,118.7	194,779.8

Source: Soil Conservation Service, USDA. Basic Statistics, 1982 National Resource Inventory. Iowa State University Statistical Laboratory, Statistical Bulletin No. 756. Table 43a. 1987.

Table 1-2. FEMA Estimate of Floodplain Area in Identified Floodprone Communities, by State, 1991.

STATE	TOTAL AREA (SQ. MI.)	TOTAL AREA (ACRES)	FLOODPLAIN AREA (SQ. MI.)	FLOODPLAIN AREA (ACRES)	% OF TOTAL
Alabama	50,767	32,490,880	5,237	3,351,539	10.3
Alaska	570,833	365,333,120	731	467,714	0.1
Arizona	113,508	72,645,120	2,618	1,675,759	2.3
Arkansas	52,078	33,329,920	9,206	5,891,724	17.7
California	156,299	100,031,360	6,831	4,372,107	4.4
Colorado	103,595	66,300,800	1,587	1,015,610	1.5
Connecticut	4,872	3,118,080	285	182,143	5.8
Delaware	1,932	1,236,480	199	127,494	10.3
Dist. Columbia	63	40,320	1	843	2.1
Florida	54,153	34,657,920	10,034	6,421,910	18.5
Georgia	58,056	37,155,840	3,548	2,270,736	6.1
Hawaii	6,425	4,112,000	59	37,683	0.9
Idaho	82,412	52,743,680	548	351,028	0.7
Illinois	55,645	35,612,800	4,559	2,917,537	8.2
Indiana	35,932	22,996,480	2,627	1,681,457	7.3
Iowa	55,965	35,817,600	2,288	1,464,373	4.1
Kansas	81,778	52,337,920	3,790	2,425,872	4.6
Kentucky	39,669	25,388,160	2,120	1,356,658	5.3
Louisiana	44,521	28,493,440	12,180	7,795,336	27.4
Maine	30,995	19,836,800	906	579,620	2.9
Maryland	9,837	6,295,680	676	432,781	6.9
Massachusetts	7,824	5,007,360	547	350,203	7.0
Michigan	56,954	36,450,560	657	420,193	1.2
Minnesota	79,548	50,910,720	2,778	1,777,987	3.5
Mississippi	47,233	30,229,120	8,217	5,259,126	17.4
Missouri	68,945	44,124,800	5,143	3,291,379	7.5
Montana	145,388	93,048,320	1,072	685,947	0.7
Nebraska	76,644	49,052,160	3,079	1,970,681	4.0
Nevada	109,894	70,332,160	1,880	1,203,215	1.7
New Hamp.	8,993	5,755,520	239	153,043	2.7
New Jersey	7,468	4,779,520	958	613,196	12.8
New Mexico	121,335	77,654,400	1,868	1,195,755	1.5
New York	47,377	30,321,280	1,557	996,494	3.3
N. Carolina	48,843	31,259,520	5,265	3,369,309	10.8
N. Dakota	69,300	44,352,000	1,432	916,527	2.1
Ohio	41,004	26,242,560	1,907	1,220,231	4.7
Oklahoma	68,655	43,939,200	3,085	1,974,355	4.5
Oregon	96,184	61,557,760	1,459	933,921	1.5
Pennsylvania	44,888	28,728,320	1,021	653,280	2.3
Rhode Island	1,055	675,200	73	46,720	6.9
South Carolina	30,203	19,329,920	3,935	2,518,550	13.0
South Dakota	75,952	48,609,280	2,057	1,316,412	2.7
Tennessee	41,155	26,339,200	2,336	1,494,888	5.7
Texas	262,017	167,690,880	16,837	10,775,553	6.4
Utah	82,073	52,526,720	809	518,003	1.0
Vermont	9,273	5,934,720	226	144,950	2.4
Virginia	39,704	25,410,560	1,979	1,266,436	5.0
Washington	66,511	42,567,040	1,668	1,067,478	2.5
West Virginia	24,119	15,436,160	420	268,971	1.7
Wisconsin	54,426	34,832,640	3,001	1,920,680	5.5
Wyoming	96,989	62,072,960	1,064	681,009	1.1
TOTAL	3,539,289	2,265,144,960	146,601	93,824,412	4.1

Source: Donnelley Marketing Information Service. System Update Report. 1987. (Refinement of 1987 study based on remeasurement of Special Flood Hazard Areas in the top 2,000 communities having property at risk and a statistical adjustment to the other floodprone properties.) FEMA, 1991.

It should be emphasized that these various estimates of floodplain land in the United States are not entirely comparable. Even the 1977 and 1982 estimates made by the SCS are not directly comparable due to procedural and technological changes in data collection and statistical estimation (Soil Conservation Service, 1987). In addition, the WRC, SCS and FEMA estimates are calculated differently. The WRC estimates are based on the total amount of land in the United States. The SCS's floodprone data for the NRI pertain only to the nonfederal rural lands of the Nation and excludes most urban and built-up areas. FEMA data is based on floodplain area in communities identified by FEMA as floodprone, which in many cases excludes rural land, but in other cases includes extensive rural areas.

RIVERINE FLOODING

Overbank flooding of rivers and streams — the increase in volume of water within a river channel and the overflow of water from the channel onto the adjacent floodplain — represents the classic flooding event that most people associate with the term "flood." In fact, this is also the most common type of flood event. Hundreds of riverine floods, great and small, occur annually in the United States. However, there is no readily available estimate of the actual number of floods of a particular magnitude or return frequency that occur in any given year. Such estimates could perhaps be developed by an examination of the peak flow records on streams gaged by the U.S. Geological Survey (USGS), but to date, no such analysis is known to have been carried out.

Riverine floodplains range from narrow, confined channels (as in steep river valleys in hilly and mountainous areas) to wide, flat areas (as in much of the midwest and in many coastal areas). In the steep, narrow valleys, flooding usually occurs quickly and is of short duration, but is likely to be rapid and deep. In relatively flat floodplains, areas may remain inundated for days or even weeks, but floodwaters are typically slow-moving and shallow.

Along major rivers with very large drainage basins, the timing and elevations of flood peaks can be predicted far in advance and with considerable accuracy. In very small basins, flooding may be more difficult to predict with useful warning lead time. Generally, the smaller the drainage basin, the more difficult it is to forecast the flooding.

Flooding in large rivers usually results from large-scale weather systems generating prolonged rainfall over wide areas. These same weather systems may cause flooding in hundreds of smaller basins that drain into the major river system. The small rivers and streams are also susceptible to flooding from more localized weather systems that cause intense rainfall over only a small area. In some parts of the northern and western United States, annual spring floods result from spring snowmelt; and the extent of the flooding is dependent upon the winter snowpack and spring weather patterns.

Several high-risk or unusual types of riverine flooding are described on the following pages. There is often no sharp distinction between flash floods, flooding due to structural failure or overtopping, flooding on alluvial fans, and the other types of high-risk flooding described. There is much overlap among these types of flooding which tend to represent different characteristics of the entire range of riverine flooding. Nevertheless, the categories that follow are widely recognized and helpful in considering not only the range of flood risk but also appropriate responses to the risk.

FLASH FLOOD AREAS

"Flash flood" is a term widely used by flood experts and the general population. There is, however, no single definition of the term and no clear means to separate flash floods from the rest of the spectrum of riverine floods. Flash floods are characterized by a rapid rise in water, high velocity, and large amounts of debris. They are capable of tearing out trees, undermining buildings and bridges and scouring out new channels. Major factors in flash flooding are the intensity and duration of rainfall and the steepness of watershed and stream gradients. The amount of watershed vegetation, the natural or artificial flood storage areas, and the configuration of the streambed and floodplains are also important. In general, the more intense the rainfall and the longer it rains in a given area, the greater the probability of flash flooding. While stationary or slow-moving thunderstorms produce the most serious flash floods because of the intensity and duration of these storms, a series of fast moving storms over a short time can also produce huge volumes of runoff.

Flash flooding occurs in all 50 states and is a problem in several types of areas: on alluvial fans; in narrow and steep valleys; on overgrazed, burnt over or otherwise denuded areas; along drainage courses in urban settings; below unsafe dams; and behind unsafe or inadequate levees. Flash flooding is also a problem upon release of ice jam flooding. Flash flooding occurs most commonly in steeply sloping valleys in mountainous areas, but can also occur along small waterways in urban environments. Flash flooding in urban areas is an increasingly serious problem due to removal of vegetation, placement of debris in channels, and construction of culverts and bridges that obstruct flood flows. Also adding to the problem are paving and other replacement of ground cover by impermeable surfaces that increase runoff, and construction of drainage systems that increase the speed of runoff.

The damages caused by flash floods can be more severe than ordinary riverine floods because of the speed with which flooding occurs (this speed may hinder evacuation or protection of property), the high velocity of water, and the debris load. In addition, more than one flood crest may occur when a flash flood results from a series of fast moving storms. Sudden destruction of structures and washout of access routes may result in loss of life. A high percentage of flood-related deaths results from motorists underestimating the depth and velocity of flood waters and attempting to cross swollen streams (Federal Emergency Management Agency, 1987).

ALLUVIAL FANS

Alluvial fans, which occur mainly in dry mountainous regions, are deposits of rock and soil that have eroded from mountainsides and accumulated on valley floors in a fan-shaped pattern. The deposits are narrow and steep at the head of the fan, broadening as they spread out onto the valley floor. As rain runs off steep valley walls, it gains velocity, carrying large boulders and other debris. When the debris fills the runoff channels on the fan, flood waters spill out and cut new channels. The process is then repeated, resulting in shifting channels and combined erosion and flooding problems over a large area. Figure 1-2 illustrates the major factors affecting flood hazards on alluvial fans and Figure 1-3 identifies the several different hydraulic zones on a typical fan.

Alluvial fans are common in several states, including Arizona, California, Idaho, Montana, Nevada, New Mexico, Utah, Washington and Wyoming. Some fans are also found in Alaska, Kentucky, Tennessee and West Virginia. A study by the U.S. Army Natick Lab identified over 3,800 alluvial fans within a 19,500 square mile area of the southwest United States and estimated that over 30 percent of American southwest deserts are occupied by alluvial fans (Roberts, 1984). These include many urban areas such as Los Angeles and Clark County (Las Vegas). Often the entire area of the fan is at high risk because of the high velocity of the water and because the erosion and drainage channels meander over the fan (Bond, 1988).

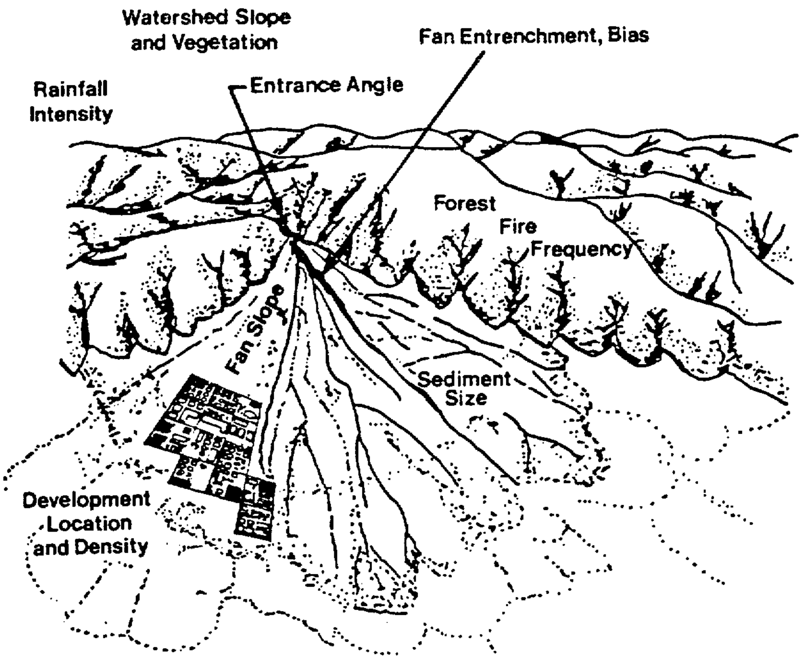
Like flash floods, flooding on alluvial fans can cause greater damage than typical riverine flooding due to the high velocity of water flow, the amount of debris carried, and the broad area affected by floodwaters. Floodwaters move at high velocities (15 to 30 feet per second are common) due to steep slopes and lack of vegetation. At these velocities, water has tremendous erosive force and damage potential. In addition, floodwaters in alluvial fans contain large amounts of sediment and debris, including boulders and trees. Since floodwaters are not confined to a single channel, but travel through numerous meandering channels, development over a broad area can be threatened.

Human activities often exacerbate flood and erosion problems on alluvial fans. Roads act as drainage channels, carrying high velocity flows to lower portions of the fan, while fill, leveling, grading and structures built in the fan can divert waters and alter expected patterns of flooding and erosion (Federal Emergency Management Agency, 1987).

UNSTABLE AND MEANDERING CHANNELS

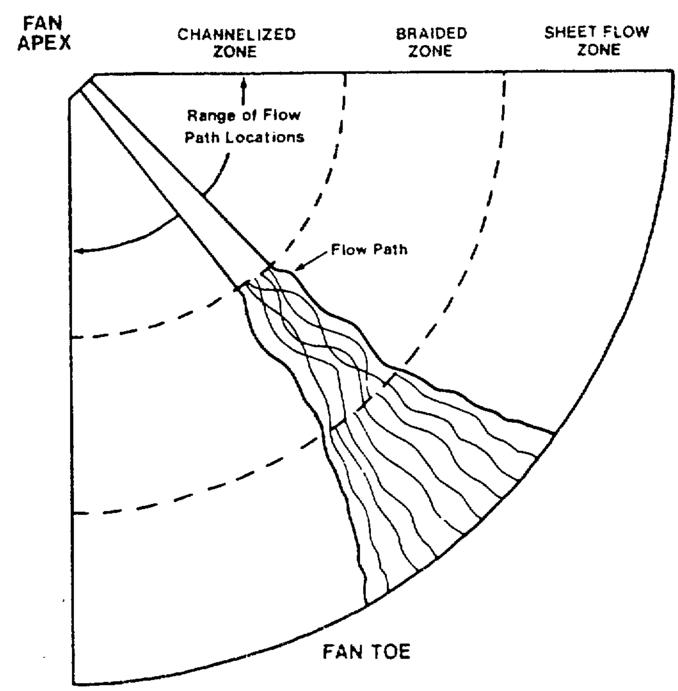
The geomorphology of many stream channels has been changed in relatively recent times by a variety of human activities. This is particularly true in the arid and semiarid regions of the western United States. Prior to the arrival of the first Europeans, and in many areas perhaps up until the middle of this century, runoff occurred mostly as sheetflow or within very minor braided sandy channels. Floodplains were wide grassy swales with riparian and deep-rooted plants. Floodwaters moved slowly in the floodplains with a great deal of infiltration and floodplain storage.

This pattern has been significantly modified. Overgrazing by cattle and other animals has altered the vegetative cover on the slopes and in the floodplains, generally increasing runoff and erosion. Mining, forestry practices and urbanization have altered the supply of sediment to the channels, as have water supply and flood control dams. The extraction of materials from the streambeds themselves has also disrupted sediment equilibrium. Surface water patterns and the movement of sediment have been altered by the construction of railroads, highways and irrigation facilities. Floodplain vegetation has been changed by diversions of surface water and the lowering of water tables.



Source: Federal Emergency Management Agency. Reducing Losses in High Risk Flood Hazard Areas: A Guidebook for Local Officials FEMA 116. Washington, D.C.: FEMA, 1987.

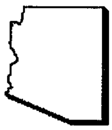
Figure 1-2. Factors Affecting Flood Hazards on Alluvial Fans.



Source: Federal Emergency Management Agency. Reducing Losses in High Risk Flood Hazard Areas: A Guidebook for Local Officials FEMA 116. Washington, D.C.: FEMA, 1987.

Figure 1-3. Hydraulic Zones on a Typical Alluvial Fan.

The cumulative result of these changes can cause rapid and often unpredictable responses in the relatively unstable stream channels during floods, including more rapid aggradation and degradation of stream channels. Degradation (deepening) of a channel may migrate upstream and into tributaries. Degradation may also lead to channel meander when the stream attempts to reach a new equilibrium between slope and sediment load.



In a channel estimated to have a capacity of about 40,000 cubic feet per second (cfs) at Tucson, Arizona, scour during a flood of 52,700 cfs lowered the channel bottom enough that overbank flooding did not occur. A 1980 flood in the Gila River downstream from Phoenix, Arizona deposited over ten feet of sediment in the main channel, causing the discharge from a one percent annual chance flood to inundate the 0.2 percent annual chance ("500-year") floodplain, as it was calculated using an assumption of a stable bed (Bond, 1988).

ICE JAM FLOODING

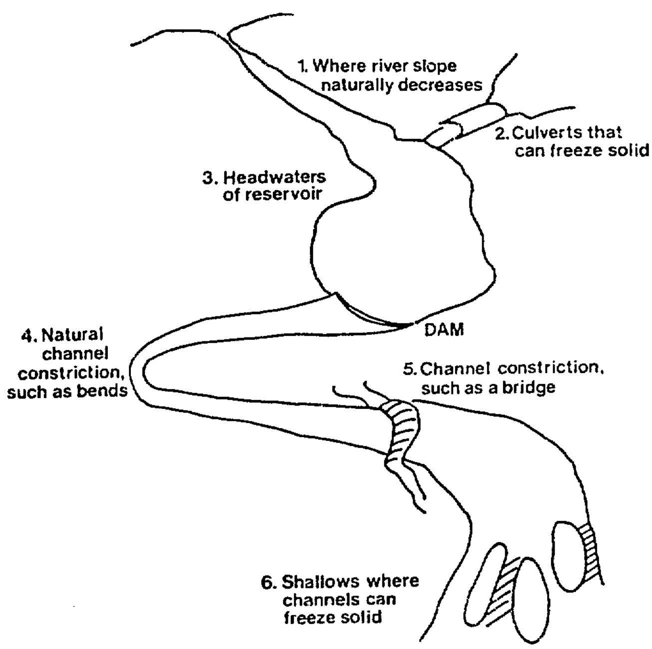
Flooding caused by ice jams is similar to flash flooding — the formation of a jam results in a rapid rise of water both at the point of the jam and upstream; failure of the jam results in sudden flooding downstream. Ice jam flooding is a problem in 35 states. States particularly prone to such flooding are Alaska, Idaho, Illinois, Iowa, Maine, Minnesota, New Hampshire, North Dakota, Oregon, Vermont, Washington, and Wisconsin.

The formation of ice jams depends on both the weather and the physical conditions in the river channel. Flooding due to ice jams (or other ice conditions) can occur at different times and in different ways. Figure 1-4 illustrates areas where ice jams are most likely to develop.

Flooding during fall freeze-up can result from the formation of frazil ice, which forms when temperatures drop but a swift current prevents the formation of a solid ice cover. The frazil ice floats downstream until it reaches a slower moving, frozen area and attaches itself to the underside of the ice cover (at times accumulating to form a hanging dam) or to the stream bed, forming anchor ice.

Ice-related flooding also occurs during mid-winter periods of very low temperature when water in the stream channel freezes completely solid, forming anchor ice. Additional water coming down the stream freezes on top of the solid ice until the channel is blocked and the stream flows overland, flooding and freezing on adjacent lands. Solid ice formed in this way frequently blocks culverts.

The classic ice jam occurs at spring breakup due to a combination of ice conditions. Generally, rising water levels in the river or stream resulting from snowmelt or rainfall break the existing ice cover into large, floating ice masses that lodge at bridges or other constrictions and create ice dams. Rapid flooding may occur, first upstream, then downstream as the mass of ice and water finally breaks free. Huge ice masses moving downstream can shear off trees and destroy buildings above the level of the flood waters. Floating ice masses and their associated damages also occur in lakes.



Source: Federal Emergency Management Agency. Reducing Losses in High Risk Flood Hazard Areas: A Guidebook for Local Officials FEMA 116. Washington, D.C.: FEMA, 1987.

Figure 1-4. Areas of Likely Ice Jam Formation.

As with other types of unique flood situations, damages from ice jam flooding usually exceed those of clear water flooding. Flood elevations are usually higher than predicted for free flow conditions, and water levels upstream and downstream increase rapidly. Additional physical damage is caused by the force of the ice floes (Federal Emergency Management Agency, 1987).

FLOODING FROM SURFACE RUNOFF, URBAN DRAINAGE AND HIGH GROUND-WATER LEVELS

Locally heavy precipitation may produce flooding in areas other than delineated floodplains. If local drainage conditions are inadequate to accommodate the precipitation through a combination of infiltration and surface runoff, water may accumulate in areas that may cause flooding problems. During winter and spring, frozen ground and accumulations of snow may contribute to inadequate drainage and localized ponding of runoff generated by precipitation and snowmelt. Flooding problems of this nature generally increase as areas become more urbanized.

Quantitative relationships have been established between land use and runoff. One study found that as population density increased from 100 to 13,000 persons per square mile, the peak rate of surface runoff became about 10 times greater (Delleur, 1982). While the specific correlations may vary from area to area and are dependent on the measure of development used, population density generally increases the amount of impervious area, resulting in an increase in the amount of surface runoff generated. Uncontrolled, this runoff may be channelled to areas that cause flooding of structures and roadways. This may be especially true where the predevelopment land surface had a gently sloping surface with no defined channels. Such areas are subject to shallow sheet flooding during storms, but urbanization and other development speeds the accumulation of flood waters.

A second major change that occurs as a result of urbanization is the development of a drainage network to control the increased runoff. The straightening and lining of channels, construction of sewers, culverts and other means of controlling runoff result in improved hydraulic efficiency of the local drainage network. In other words, the time required for surface runoff to reach a channel is reduced. Unless the drainage network is specifically designed to counteract this increase in rate of runoff from the watershed, the result is likely to be an increase in flood peaks (Delleur, 1982).

High ground-water levels may also be of concern and can cause flooding problems in areas and at times where there is no surface flooding. Basements are most susceptible to flooding from high ground-water levels. Seasonally high ground water is common in many areas, while in other areas high ground-water is a problem only after long periods of above average precipitation.

COASTAL FLOODING AND EROSION

Coastal flooding and erosion are serious problems along much of the Nation's coasts, although the frequency and magnitude of the flooding and the severity of the erosion vary considerably. Great Lakes flooding — often considered as coastal flooding — is discussed separately toward the end of this chapter.

Coastal flooding and erosion result from storm surge and wave action. Storm surge is the increase in water surface elevation above normal tide levels due primarily to low barometric pressure and the piling up of waters in coastal areas as a result of wind action over a long stretch of open water. Depending upon local topography, a storm surge may inundate only a small area (such as along sections of the Northeast and Northwest coasts) or may inundate coastal lands for a mile or more inland from the shoreline (as in many areas of the south Atlantic and Gulf coasts).

In addition to storm surge, wave action is an important aspect of coastal storms. Breaking waves at the shoreline become very destructive, causing damages to natural and manmade structures by hydrodynamic pressure, battering solid objects and scouring sand from around foundations. Components of wave action include wave set-up and wave run-up. Wave set-up is the super-elevation of the water surface over normal surge elevation and is caused by onshore mass transport of the water by wave action alone. Wave run-up is the action of a wave after it breaks and the water "runs up" the shoreline or other obstacle, flooding areas not reached by the storm surge itself. Where vertical obstructions such as seawalls are present, wave run-up is translated into upward movement of the water.

As waves move toward the shore, they encounter several obstacles. The first obstacle is the sloping bottom near the shoreline. When waves reach a water depth equal to about 1.3 times the wave height, the wave breaks. Breaking waves dissipate their energy by generating turbulence in the water and by transporting sediment lifted off the bottom and tossed around by the turbulent water. As the turbulent water travels forward, it expends most of its remaining energy as it rushes up the beach slope. The beach adjusts to changes in wave energy by changing its profile. Beach material is moved either seaward, creating an offshore berm, or landward, building up the beach. The beach is constantly adjusting to both wave energy and water level.

Offshore berms built up by the natural action of waves serve to protect the beach from most storm waves. When major storms generate larger waves, the berm may be eroded and berm material carried offshore. With the protective value of the berm removed, large waves can overtop the beach. In severe storms such as hurricanes, 60- to 100-foot wide dunes may disappear in only a few hours. Although the dunes and beach may eventually recover to their previous conditions, the process may require many years (U.S. Army Corps of Engineers, 1984). Figure 1-5 provides a schematic diagram of storm wave attack on a beach and dune system.

TROPICAL STORMS AND HURRICANES

Tropical cyclones[4] of various intensities form over warm tropical and subtropical waters, sometimes developing into mature hurricanes, and eventually dissipate over the colder waters of the North Atlantic or when the storms move over land. Tropical cyclones generally range in size from 100 to 600 nautical miles in diameter at maturity, with sustained wind speeds often exceeding 100 knots near the center. Occasionally, sustained winds exceeding 150 knots occur in well-developed systems. Damages from tropical cyclones result from the high winds (including associated tornadoes), torrential rains over large areas, and coastal storm surge of 10 to 25 feet above normal in extreme cases. Historically, coastal storm surge has been the major cause of deaths and damages from these storms in the United States.

A total of 785 tropical cyclones was recorded over the Atlantic tropical cyclone basin from 1899 to 1989. Of these, 159 hurricanes and 138 tropical storms (a total of 297 or about 39%) crossed or passed adjacent to the United States mainland (Texas to Maine), for an annual average of 1.5 tropical storms and 1.8 hurricanes (Neumann, 1987; Jarvinen, 1990). Figure 1-6 shows the annual distribution of these tropical storms and hurricanes. Figure 1-7 shows the incidence of landfalling tropical storms and hurricanes along the United States coastline from Texas to Maine for the period 1871-1984.

Meteorological and geographical factors influence hurricane or storm damage relative to any given storm track. For example, the pattern of wind, rainfall, storm surge, and associated damage is rarely symmetrical about the storm track. Also, wind gusts, which may be greater than sustained wind speeds, must be considered in assessing damage potential.

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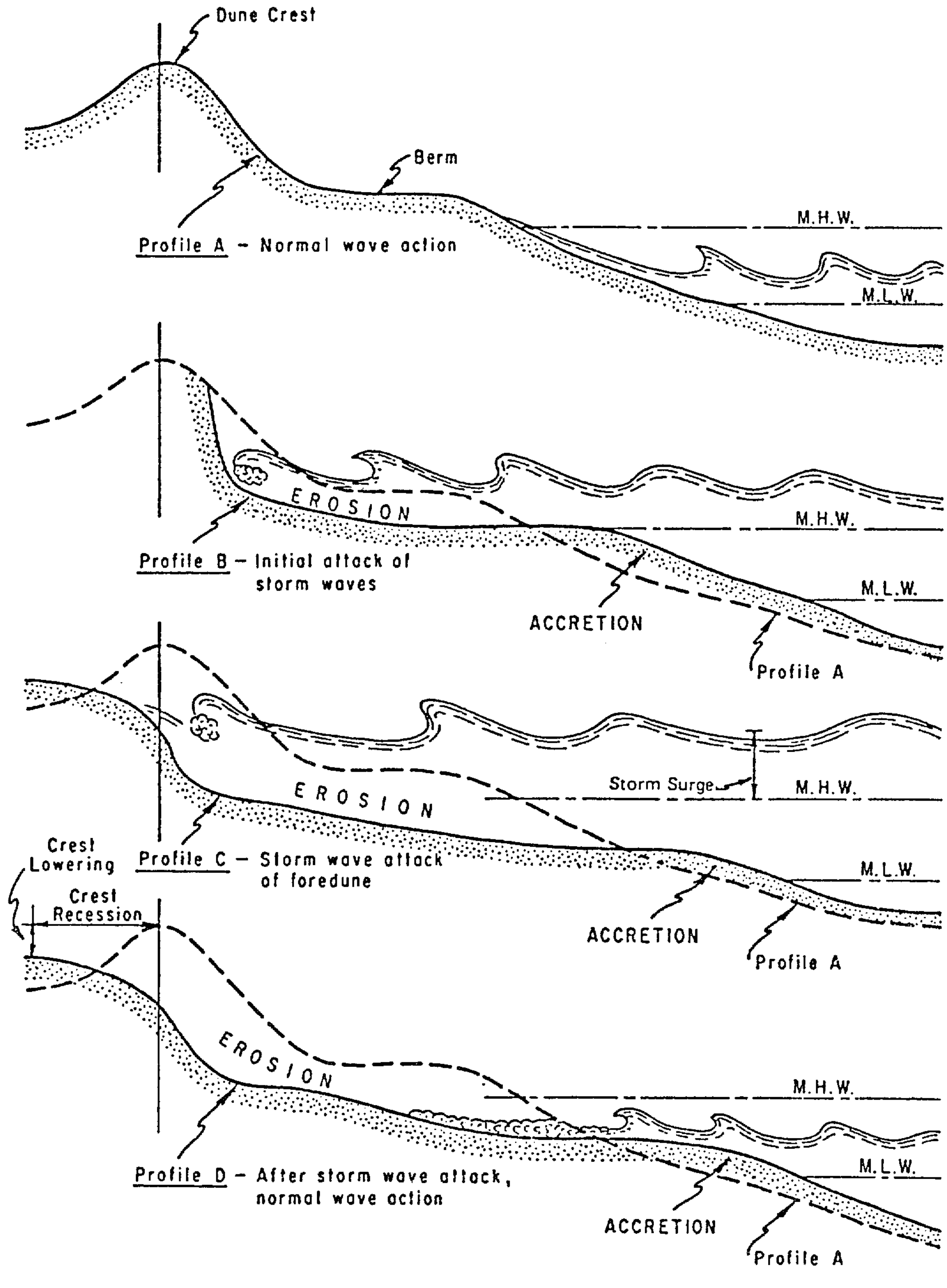
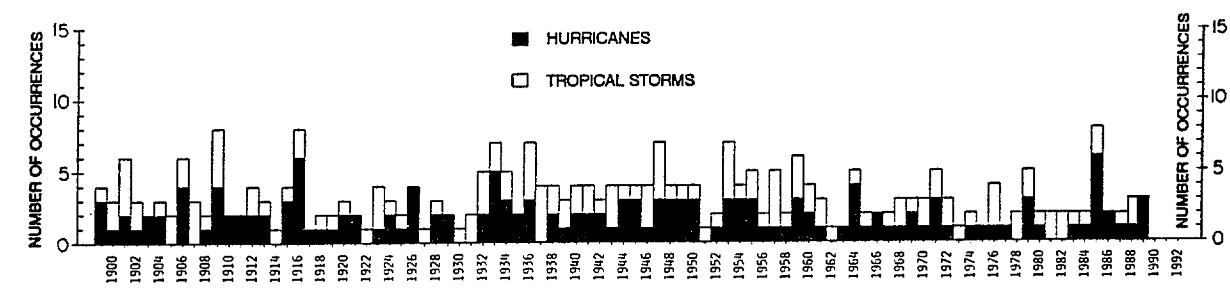
4 Several categories of tropical cyclones are recognized according to their intensity and degree of organization:
(1) tropical disturbance (little or no rotary circulation at the surface and no strong winds);
(2) tropical depression (winds equal to or less than 38 mph);
(3) tropical storm (winds of 39 mph or more); and
(4) hurricane (winds of 74 mph or more).



Source: U.S. Army Corps of Engineers, Waterways Experiment Station. Shore Protection Manual Volume I. Vicksburg, Mississippi: U.S. Army Corps of Engineers, 1984.

Figure 1-5. Schematic Diagram of Storm Wave Attack on Beach and Dune.



Annual distribution of the 138 Atlantic tropical storms (open bars) and the 159 hurricanes (solid bars) that have crossed or passed immediately adjacent to the United States coastline (Texas to Maine), 1899 through 1989. The average annual number of such storms is 1.5 and 1.8 respectively. Graph displays one crossing per storm even though multiple crossings may have occurred.

Source: Neumann, Charles J., B. R. Jarvinen and A. C. Pike. Tropical Cyclones of the North Atlantic Ocean, 1871-1986. Asheville, North Carolina: National Climatic Data Center, 1987. Updated through 1989 by B.R. Jarvinen, National Hurricane Center, National Weather Service.

Figure 1-6. Annual Distribution of Atlantic Tropical Storms that have Crossed or Passed Adjacent to the United States, 1899-1989.

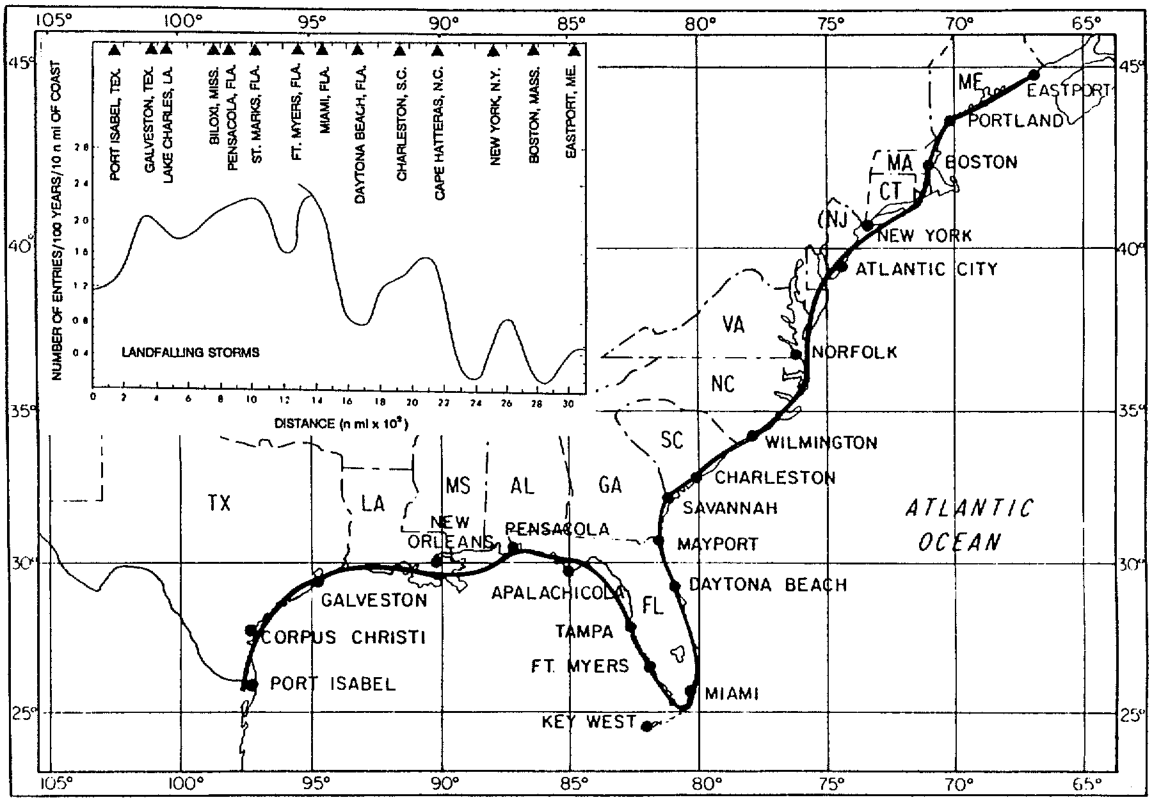
The National Hurricane Center (NHC) has adopted the Saffir/Simpson Hurricane Scale, which relates hurricane intensity to damage potential. Figure 1-8 shows that this scale divides hurricanes into five intensity categories, with category 5 being the most intense. Table 1-3 shows that the NHC has determined that a total of 148 category 1 through 5 hurricanes crossed the United States coastline at one or more points (an average of 5 hurricanes every 3 years) between 1899 and 1986, including 59 major hurricanes (category 3 or higher). Thus, major hurricanes capable of causing damage in the billions of dollars and killing hundreds of people have crossed the United States coastline about twice every 3 years (Neumann, 1987).

Hurricanes are not exclusively a problem of the Gulf and Atlantic coasts. Pacific hurricanes (called typhoons) develop in the regions off Mexico and Central America and move up the Pacific coast. While much less frequent and generally less severe than Atlantic hurricanes, these typhoons can cause much damage. Typhoons also affect Hawaii in the central Pacific and Guam and the Northern Mariana Islands in the western Pacific.

OTHER COASTAL STORMS

While hurricanes are the most violent type of storm and receive the most attention, serious flooding and erosion problems are also caused by other coastal storms. On the Pacific coast, storm patterns roll in from the Pacific ocean, sometimes in a series.

In the Atlantic, extratropical storms that develop in mid-latitudes in the fall, winter and spring (most commonly November through April) occur much more frequently than tropical cyclones, and may be more than 1,000 miles in diameter, much larger than a tropical cyclone. Although maximum winds are of lower velocity than tropical cyclone winds, some wind gusts of hurricane velocity may occur with extratropical storms.



Note: Certain factors should be considered before making inferences from Figure 1-7. First, the chart includes all storms, ranging from weak tropical storms to the most intense hurricanes. Second, the frequencies represent long-term averages. For shorter (10- or 20-year) periods, considerable deviation has occurred and will continue to occur in the future. For example, from 1951 through 1960, many more major hurricanes struck the East Coast of the United States than affected the Gulf of Mexico Coast. Figure 1-7 does not address these short-period variations.

Another factor to be considered pertains to the proper interpretation of the term "per 10 nautical miles of coastline." In the Miami area, about 2 storms per 100 years per 10 nautical miles of coast are indicated. This should not be interpreted to mean that Miami area expects 2 storms per century. Storms that strike along the coast in other 10 nautical mile segments, both south and north of Miami, would also affect the area. Indeed, the damage swath from a major hurricane can cover more than 100 miles of coastline.

Source: Neumann, Charles J., B. R. Jarvinen and A. C. Pike. Tropical Cyclones of the North Atlantic Ocean, 1871-1986. Asheville, North Carolina: National Climatic Data Center, 1987.

Figure 1-7. Smoothed Frequency of Landfalling Tropical Storms and Hurricanes for the Gulf and East Coasts of the United States, 1871-1984.

THE SAFFIR/SIMPSON HURRICANE SCALE

Scale No. 1 - Winds of 74 to 95 miles per hour. Damage primarily to shrubbery, trees, foliage, and unanchored mobile homes. No real damage to other structures. Some damage to poorly constructed signs. And/or: storm surge 4 to 5 feet above normal. Low-lying coastal roads inundated, minor pier damage, some small craft exposed, anchorage torn from moorings.

Scale No. 2 - Winds of 96 to 110 miles per hour. Considerable damage to shrubbery and tree foliage: some trees blown down. Major damage to exposed mobile homes. Extensive damage to poorly constructed signs. Some damage to roofing materials of buildings. And/or: storm surge 6 to 8 feet above normal. Coastal road and low-lying escape routes inland cut by rising water 2 to 4 hours prior to arrival of hurricane center. Considerable damage to piers. Marinas flooded. Evacuation of some shoreline and low-lying inland areas required.

Scale No. 3 - Winds of 111 to 130 miles per hour. Foliage torn from trees: large trees blown down. Practically all poorly constructed signs blown down. Some damage to roofing materials of buildings: some window and door damage. Some structural damage to small buildings. Mobile homes destroyed. And/or: storm surge 9 to 12 feet above normal. Serious flooding at coast and many smaller structures near coast destroyed: larger structures near coast damaged by battering waves and floating debris. Low-lying escape routes inland cut by rising water 3 to 5 hours before hurricane center arrives. Major erosion of beaches. Massive evacuation of all residences within 500 yards of shore possibly required, and of single-story residences on low ground within 2 miles of shore.

Scale No. 4 - Winds of 131 to 155 miles per hour. Shrubs and trees blown down; all signs down. Extensive damage to roofing materials, windows and doors. Complete failure of roofs on many small residences. Complete destruction of mobile homes. And/or: storm surge 13 to 18 feet above normal. Flat terrain 10 feet or less above sea level flooded inland as far as 6 miles. Major damage to lower floors of structures near shore due to flooding and battering by waves and floating debris. Low-lying escape routes inland cut by rising water 3 to 5 hours before hurricane center arrives. Major erosion of beaches. Massive evacuation of all residences within 500 yards of shore possibly required and of single-story residences on low ground within 2 miles of shore.

Scale No. 5 - Winds greater than 155 miles per hour. Shrubs and trees blown down; considerable damage to roofs of buildings; all signs down. Very severe and extensive damage to windows and doors. Complete failure of roofs on many residences and industrial buildings. Extensive shattering of glass in windows and doors. Some complete building failures. Small buildings overturned or blown away. Complete destruction of mobile homes. And/or: storm surge greater than 18 feet above normal. Major damage to lower floors of all structures less than 15 feet above sea level within 500 yards of shore. Low-lying escape routes inland cut by rising water 3 to 5 hours before hurricane center arrives. Massive evacuation of residential areas on low ground within 5 to 10 miles of shore possibly required.

Source: Neumann, Charles J., B. R. Jarvinen and A. C. Pike. Tropical Cyclones of the North Atlantic Ocean, 1871-1986. Asheville, North Carolina: National Climatic Data Center, 1987.

Figure 1-8. The Saffir/Simpson Hurricane Scale.

Table 1-3. Number of Hurricanes (Direct Hits) Affecting the United States and Individual States, 1899-1989, Categorized According to Saffir/Simpson Hurricane Scale.

AREA	CATEGORY 1	2	3	4	5	ALL	MAJOR HURRICANES (≥ CATEGORY 3)
U.S. (Texas to Maine)	55	34	44	13	2	148	59
Texas	10	9	9	6	0	34	15
(North)	7	3	3	4	0	17	7
(Central)	2	2	1	1	0	6	2
(South)	3	4	5	1	0	13	6
Louisiana	8	5	7	3	1	24	11
Mississippi	1	1	5	0	1	8	6
Alabama	4	1	5	0	0	10	5
Florida	16	15	16	5	1	53	22
(Northwest)	9	7	6	0	0	22	6
(Northeast)	1	7	0	0	0	8	0
(Southwest)	5	3	5	2	1	16	8
(Southeast)	5	10	7	3	0	25	10
Georgia	1	4	0	0	0	5	0
South Carolina	7	4	2	*2	0	15	4
North Carolina	11	4	8	*1	0	24	9
Virginia	1	1	*1	0	0	3	1
Maryland	0	*1	0	0	0	1	0
New Jersey	*1	0	0	0	0	1	0
New York	3	0	*5	0	0	8	5
Connecticut	*2	2	*3	0	0	7	3
Rhode Island	0	*1	*3	0	0	4	3
Massachusetts	2	*1	*2	0	0	5	2
New Hampshire	*1	*1	0	0	0	2	0
Maine	*5	0	0	0	0	5	0

Note: Asterisk (*) indicates that all hurricanes in this category were moving in excess of 25 miles per hour.

Source: Neumann, Charles J., B. R. Jarvinen and A. C. Pike. Tropical Cyclones of the North Atlantic Ocean, 1871-1986. Asheville, North Carolina: National Climatic Data Center, 1987. Updated through 1989 by B.R. Jarvinen, National Hurricane Center, National Weather Service.

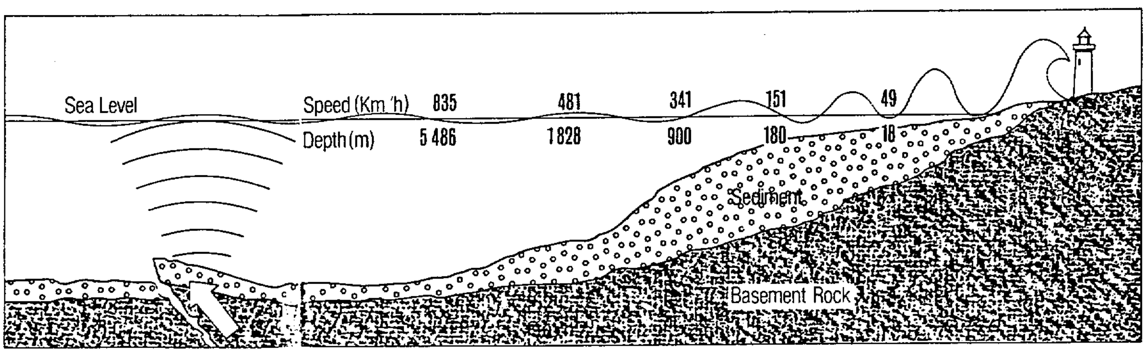
Extratropical storms that occur along the northern part of the east coast of the United States, accompanied by strong winds blowing from the northeast quadrant, are called northeasters. Northeasters may stall off the coast of the North Atlantic states and produce high tides that persist for several days.

A study of northeasters affecting the Atlantic coastal margin of the United States during the period 1921-1962 (Mather, 1965) found that during the 42-year period of record, 34 extratropical storm events occurred that resulted in water-related damage (i.e., damage due to wave action and tidal flooding). The recurrence interval of such storm events is 1.24 years. Stated in another way, a storm of this nature has an 81% chance of occurrence in a given year, based on the observed data (Long Island Regional Planning Board, 1984).

TSUNAMIS

The term "tsunami" is used to describe sea waves of seismic origin. Tectonic earthquakes (earthquakes that cause a deformation of the seabed) appear to be the principal seismic mechanism responsible for the generation of tsunamis, although coastal and submarine landslides and volcanic eruptions have also triggered tsunamis.

Tsunamis, which are principally generated by undersea earthquakes of magnitudes greater than 6.5 on the Richter scale, are very long-period waves (5 minutes to several hours) of low height (a few feet or less) when traversing water of oceanic depth. Consequently, they are not discernible in the deep ocean and go unnoticed by ships. Tsunamis can travel at speeds in excess of 500 mph in the deep ocean (see Figure 1-9).



Source: Jervis, Michael. "Tsunami Warning!" Emergency Preparedness Digest, Emergency Preparedness Canada. (January-March 1990): 17.

Figure 1-9. Relative Speed of Seismic Sea Waves in Deep Water and Near Shore.

When tsunamis approach a coastal region where the water depth decreases rapidly, wave refraction, shoaling, and bay or harbor resonance cause the amplitude of the tsunami to increase significantly. The great periods and wavelengths of tsunamis preclude the dissipation of their energy as a breaking surf; instead, they are apt to appear as rapidly rising water levels and only occasionally as bores (Houston, 1980).

A tsunami may consist of only a single wave, but more often consists of a series of waves separated by a few minutes up to about an hour. The largest and most destructive waves may occur near the end of the series. The first water movement at the shore associated with a tsunami may be a rapid draw down or retreat of coastal water, exposing wide expanses of beach, floundering fish and shipwrecks. Unaware coastal residents may rush onto the exposed beach, only to be caught by the following wave (Forrester, 1987).

The rate of travel of a tsunami varies with the square root of water depth. Therefore, the arrival time of a tsunami at any particular point on shore may be predicted with considerable accuracy following detection of seismic activity. However, the size of tsunami waves cannot yet be accurately predicted. About 5 percent of recorded tsunamis produce waves of 15 feet or higher at the coast (Forrester, 1987).

Over 500 tsunamis have been reported within recorded history, virtually all of them in the Pacific Basin. Most tsunamis are associated with earthquakes, and most seismic activity beneath the oceans is concentrated in the narrow fault zones adjacent to the great oceanic trench systems that are found predominantly in the Pacific Ocean. Consequently, the entire Pacific coast of the continental United States and the Alaskan and Hawaiian coasts are subject to tsunamis (Houston, 1980).

AREAS INFLUENCED BY STRUCTURAL PROTECTIVE MEASURES

When the natural protective system (e.g., beaches and sand dunes) fails to provide adequate protection during storms, some type of artificial protection is often sought. Artificial shoreline protection may range from nonstructural measures such as beach nourishment and artificial sand dune building, to structural measures. Structural measures designed to stabilize the shore generally fall into two categories: 1) structures such as breakwaters, seawalls, bulkheads and revetments to prevent waves from reaching a harbor area; and 2) groins, jetties and similar structures used to retard longshore transport of littoral drift. Groins and jetties may be used in conjunction with seawalls and beach fill.

Protection of short reaches of an eroding shoreline, including measures to protect individual homes, may prove unsuccessful and create additional problems on adjacent properties. These small shore protection structures often fail at their flanks and the adjacent unprotected shoreline continues to erode. Erosion of adjacent shoreline may even be accelerated by partial or inadequate protective measures. Even if constructed to cover the entire reach of eroding shoreline, onshore structures such as bulkheads, seawalls, and revetments often provide only short-term erosion and flood protection because of foreshore erosion and flanking. Offshore structures such as breakwaters may provide longer term protection, but can have detrimental as well as beneficial effects on the shore. The reduction of wave action by the structure also reduces the longshore transport of sediment, which may lead to sand accretion and formation of a sandbar, as well as associated down-drift beach erosion (U.S. Army Corps of Engineers, 1984).

RELATIVE SEA LEVEL RISE AND SHORELINE RETREAT

On the average, worldwide sea level has been rising relative to land masses over the past 15,000 years as the earth's climate has warmed and as the earth has undergone tectonic activity. The change in sea level relative to land results from the combined effects of an actual rise in sea level and the upward or downward movement of land at different locations. The greenhouse effect (caused by excess production of carbon dioxide from burning fossil fuels, deforestation, and other human actions), combined with natural phenomena, warms the atmosphere and ocean waters and is primarily responsible for the rising ocean levels. Land masses are emerging in some regions due to ongoing geologic processes such as glacial rebound and movement of tectonic plates. In other areas, land is subsiding due to the extraction of oil, gas or water, as well as longer term geologic adjustments. Therefore, any discussion of sea level rise must be in the context of sea level relative to the adjacent land mass, i.e. the relative rise (or drop) of sea level.

Relative sea level rise along the northeast coast of the United States is due not only to global increases in sea level believed to be associated with the greenhouse effect, but also to a large extent from isostatic adjustment. As the North American glaciers melted over the past 10-15 thousand years, land previously covered by glaciers has adjusted to removal of the weight of the glacial mass. Land which was formerly depressed below the glaciers is now rebounding and, as a result, the relative sea level has been falling. Along the edges of the glacial mass, land was elevated somewhat and has been falling, so relative sea level has been rising (L.R. Johnston Associates, 1986).

Relative sea level rise is an underlying cause of shoreline retreat along the Gulf and Atlantic coasts and to a lesser extent along the Pacific coast. Rising sea levels have caused increased coastal flooding and erosion, and the projected accelerated rise in relative sea level over the next century is likely to cause significant increases in these problems. An increase in relative sea level of only a few inches may inundate land hundreds of feet inland from the shoreline, accelerate erosion, affect wetlands, and cause other types of changes.

The present worldwide rate of relative sea level rise is approximately one foot per century. From tide measurements, the National Ocean Service (NOS) has developed trends in the relative rise of yearly mean sea level along the United States coast for the period 1940 through 1986. The average for the entire United States coast is about 0.0066 feet per year (2 mm/yr). As shown in Table 1-4, for the Gulf coast the rate is considerably higher at 0.0095 feet per year, while for the northern west coast it is only 0.0004 feet per year (Hicks and Hickman, 1988).

Table 1-4. Trends and Variability in Relative Sea Level Rise in the United States, 1940-1986.

	TREND ± ft/yr	STANDARD ERROR ± ft/yr	VARIABILITY* ± ft/yr
Northern East Coast	.0088	.00091	.0842
Southern East Coast	.0075	.00114	.1040
Gulf Coast	.0095	.00117	.1086
Southern West Coast	.0051	.00115	.1071
Northern West Coast	.0004	.00117	.1085

* Standard Error of Estimate

Source: Hicks, Stacey D., and Leonard E. Hickman, Jr. "United States Sea Level Variations Through 1986." Shore and Beach. July 1988.

Although hardly noticeable, this slow rise has still had an effect on coastal flooding and erosion. In addition, the global warming that is largely responsible for projections of accelerated rates of sea level rise may also cause major climate changes, such as shifts in rainfall patterns, an increase in the number and intensity of tropical storms and hurricanes and other unknown effects (Barth, 1984).

Task forces assembled by the U.S. Environmental Protection Agency (EPA) and the National Academy of Sciences (NAS) during the early 1980s estimated that the rate of relative sea level rise will accelerate in the future. The EPA predicted that by the year 2100, sea level will probably rise about four feet above present levels (Hoffman, 1983). Following release of the EPA and NAS reports, the issues of global warming and relative sea level rise have received much attention and have been the subject of much additional research. Although not all researchers agree, the predominant view is that global warming is occurring and the rate of relative sea level rise will increase markedly. There appears to be, however, little agreement on predictions of the actual timing, rate and amount of relative sea level rise.[5]

GROUND FAILURE AREAS

Flooding and flood-related erosion can result from several types of ground failure. Subsidence and liquefaction of soil may cause flooding of areas in the immediate vicinity of the ground failure, while mudflows and mudfloods may cause damages downstream or downslope of the location where the initial ground failure occurred.

MUDFLOWS AND MUDFLOODS

Mudflow and mudfloods (also referred to as debris flow) are considered a subset of landslides and affect many of the nation's floodplains. Areas that have experienced the greatest landslide damage are the Appalachian region, the Rocky Mountain region, and the Pacific coast region (National Research Council, 1985). The distinction between mudflows, mudfloods and landslides is not clear since all usually occur under wet conditions and consist of a mixture of water and solids.

Landslides, an extreme form of erosion, are a natural process of the earth's surface, and occur when external forces exceed internal forces within the soil and rock of a hillside. The word "landslide" encompasses a range of processes: slumps to flows, slow to rapid movements, and small to large earth displacement. The width of landslides can range from a few feet to greater than a mile. Although earthquakes cause a great number of landslides, water from intense rainfall or human-introduced sources is the most common triggering mechanism. And while large, rapid slides are spectacular media attractions, persistently creeping slides and the cumulative effect of many small landslides cause a significant amount of damage in the United States (Federal Emergency Management Agency, 1987).

[5] See Chapter 6 for additional description of relative sea level rise.

The National Academy of Sciences (National Research Council, 1985) has defined mudflood and mudflow as follows:

- *Mudflood*: Refers to a flood in which the water carries heavy loads of sediment (as much as 50% by volume) including coarse debris. Mudfloods typically occur in drainage channels and on alluvial fans adjacent to mountainous areas, although they may occur on floodplains as well.

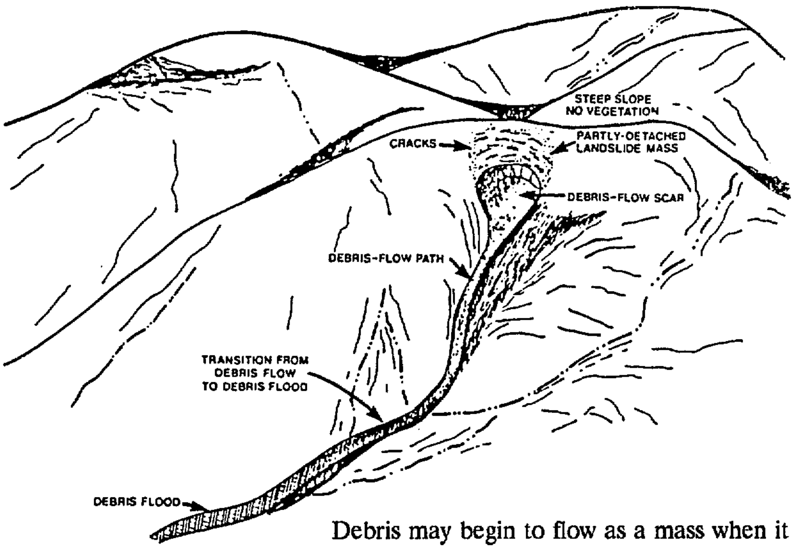
- *Mudflow*: Refers to a specific subset of landslides where the dominant transporting mechanism is that of a flow having sufficient viscosity to support large boulders within a matrix of smaller sized particles. Mudflows may be confined to drainage channels or may occur unconfined on hill slopes.

Mudflows and mudfloods are often the result of rain falling on terrain that has been denuded by forest fires and brush fires, and thus can not retain runoff. In areas where ground cover has been removed, even small rains can cause mudflows and mudfloods (see Figure 1-10). Steep lands with an identifiable subsoil layer of clay could break loose and start a mudflow when the clay layer becomes saturated. A vigorous forest cover produces roots capable of holding the soil in place. Tree cover also increases the evapotranspiration rate and assists in reducing the time that underlying clay layers are saturated. The most common mudflow resulting from slope failure in forested lands occurs about five to ten years after a major forest fire where established timber is killed. During the following years new growth is established. However, roots from the previous growth have deteriorated and the new roots are not strong enough to hold the soil from moving, thus starting a mudflow (von Wolffradt, 1988).

Both mudflows and mudfloods start with moving water or a stationary mass of saturated soil. Mudfloods usually originate as sheet flow or as water flowing in drainage channels, rivers or streams, and pick up sediment and debris as they flow. Mudflows often originate as a mixture of stationary soil and water. When the mixture gets wet enough, it begins to move as a mass, either as a result of gravity or when triggered by an earthquake or a sudden flow of debris laden water. Mudflows may also begin as clear-water flows but incorporate sediments and other debris from the stream channel or banks and "bulk up" to flows much larger than the clear-water flow before eventually dropping the debris and attenuating (Haupt, 1988). Mudflows may travel many miles from their source.

Mudflows and mudfloods may cause more severe damage than clear water flooding due to the force of the debris-filled water and the combination of debris and sediment. The force of the water often destroys pilings and other protective works, as well as structures in its path (or when structures remain intact, sediment must often be physically removed with shovels or hoses). Mud and debris may also fill drainage channels and sediment basins, causing floodwater to suddenly inundate areas outside of the floodplain (Federal Emergency Management Agency, 1987).

Although understanding of the causes of landslides and the development of improved methods for handling them has progressed, the problem continues to grow. In the last 20 years, the number of damaging landslides has increased, due largely to continuing urban expansion in areas of steeply sloping terrain and unstable slopes. This urban development alters hillslope configuration and upsets established equilibrium conditions, affecting the natural instability of many slopes and, in some cases, reactivating older landslides. It is estimated that in Los Angles County, California alone, there are 3,000 sites susceptible to hazards posed by mud and debris flows (Department of the Interior, 1989).



Debris may begin to flow as a mass when it becomes wet. Gravity, earthquakes or a sudden flow of debris-laden water could be the triggering mechanism.

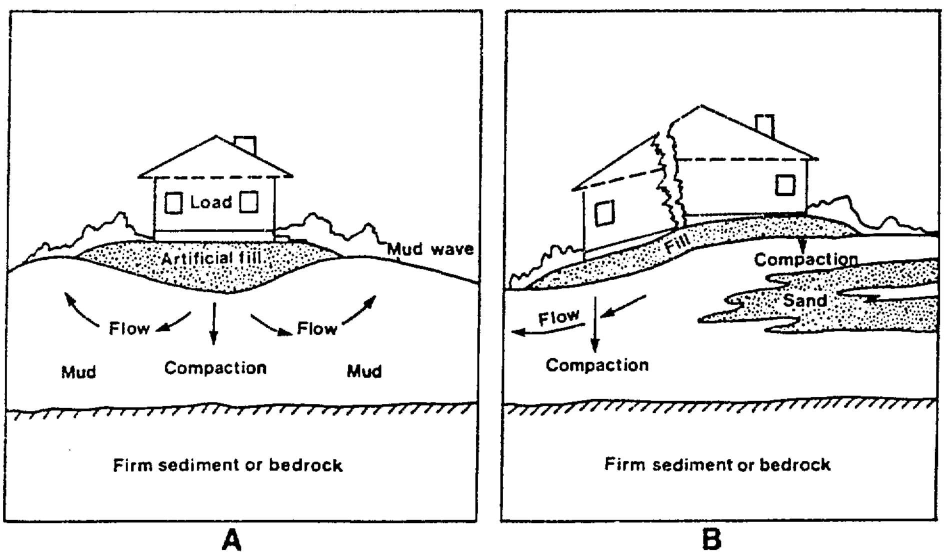
Source: Federal Emergency Management Agency. Reducing Losses in High Risk Flood Hazard Areas: A Guidebook for Local Officials FEMA 116. Washington, D.C.: FEMA, 1987.

Figure 1-10. Mudflow Areas.

SUBSIDENCE

Subsidence is a type of ground failure that can lower the ground surface, causing or increasing flood damage in areas of high ground water, tides, storm surges or overbank stream flow. Subsidence occurs in nearly all of the states (Federal Emergency Management Agency, 1987). (As previously described, mudflows and landslides are also types of ground failures.) Ground failure due to subsidence can result in increased flood damages for two main reasons. If the land surface is lowered it may be more frequently or more deeply flooded. In addition, subsidence can block or otherwise alter drainage patterns leading to deeper or unexpected flooding.

Subsidence is the result of both natural processes and human activities. Natural causes include solution (karst topography), consolidation of subsurface materials (such as wetlands soils), and movements in the earth's crust. Human activities, which frequently accelerate the natural processes leading to subsidence, include mining, inadequate compaction of fill material during construction (see Figure 1-11) and withdrawal of oil or water from subsurface deposits.



Damage due to differential compaction of soils. In "A," soils have settled homogeneously. In "B," the presence of the sand body results in differential settling with subsequent structural damage to the house.

Source: Federal Emergency Management Agency. Reducing Losses in High Risk Flood Hazard Areas: A Guidebook for Local Officials FEMA 116. Washington, D.C.: FEMA, 1987.

Figure 1-11. Damage Due to Differential Compaction of Soils.

A report by FEMA (Federal Emergency Management Agency, 1987) describes several causes of subsidence:

- The withdrawal of oil, gas and water from below the earth's surface results in the collapse of the grain structure and compaction of subsurface materials causing the land surface to sink. The harbor at Long Beach, California, for example, has subsided as much as 27 feet due to oil and gas withdrawals.
- Subsidence occurs in organic wetlands as the soils are compacted by fills and development and as ground water is withdrawn. The ground surface then settles, but not at an even rate. Development on coastal wetlands or coastal areas is most likely to experience subsidence.
- Underground mining, both past and present, is the cause of subsidence in an estimated 220 counties in 42 states.
- In areas of karst terrain, as ground water percolates through limestone, it dissolves the rock, forming cavities or caverns that cannot always be detected. Fluctuating ground-water levels can cause these caverns and overlying surface materials to collapse suddenly, forming sinkholes. The land surface can also sink slowly and irregularly, resulting in flooding.

LIQUEFACTION

Although less common than subsidence, liquefaction is another type of ground failure that contributes to flood problems. Liquefaction can result in serious flooding of structures built on fill or saturated soils, as in portions of San Francisco or Anchorage.

Liquefaction is triggered by earthquakes and occurs when seismic shock waves pass through unconsolidated and saturated soil, allowing the soil grains to move freely and pack more closely together. A soil structure with water in the pore spaces is transformed to groups of grains in a fluid matrix, and the load of the overlying soil and buildings is transferred from the soil grains to the pore water. If the pressure on the water causes it to drain away, the overlying soils and structures will sink or tilt. If the water cannot drain away, the water pressure rises. When the water pressure equals the downward pressure of the overlying strata and structures, the saturated soil layer will become liquid and flow. On steep slopes (greater than 3%) where the saturated layer is at or near the surface, soil, vegetation and debris can flow rapidly downslope with the liquified material. These flow failures can result in the movement of material for miles. On gentle slopes (0.3 to 3%) where the saturated layer is below the surface, failures termed lateral spread occur, with huge blocks of soil moving 10 to 100 feet or more (Federal Emergency Management Agency, 1987).

FLUCTUATING LAKE LEVELS

Water levels in U.S. lakes can fluctuate on a short-term (e.g., seasonal) or long-term (e.g., yearly) basis. Periods of heavy rainfall, for example, can cause high water levels for short periods of time and annual snowmelt can result in higher water levels in the spring. Long-term lake level fluctuations are a less-recognized phenomenon that can cause high water and subsequent flooding problems lasting for years or even decades.

While all types of lakes may exhibit fluctuating water levels, water levels usually do not change dramatically in lakes where outlet streams provide a fairly regular balance of inflow and outflow. Some lakes, however, are completely landlocked or have outlets that are "inadequate" for maintaining a balance between inflow and outflow. These lakes, commonly referred to as "closed basin lakes," are particularly susceptible to dramatic fluctuations in water levels — five to fifteen feet in some instances — over long periods of time. The Great Salt Lake in Utah and the Salton Sea in California are examples of landlocked lakes, and the Great Lakes are examples of lakes with inadequate outlets under extreme high water level conditions.

Long-term water level fluctuations are particularly pronounced on the Great Lakes and other lakes that were formed by glacial action. The significance of this problem is underscored by the fact that most of the lakes in the United States are glacial lakes. In the states of Alaska, Maine, Michigan, Minnesota, New York, North Dakota and Wisconsin alone, there are more than 100,000 inland lakes (Federal Emergency Management Agency, 1987).

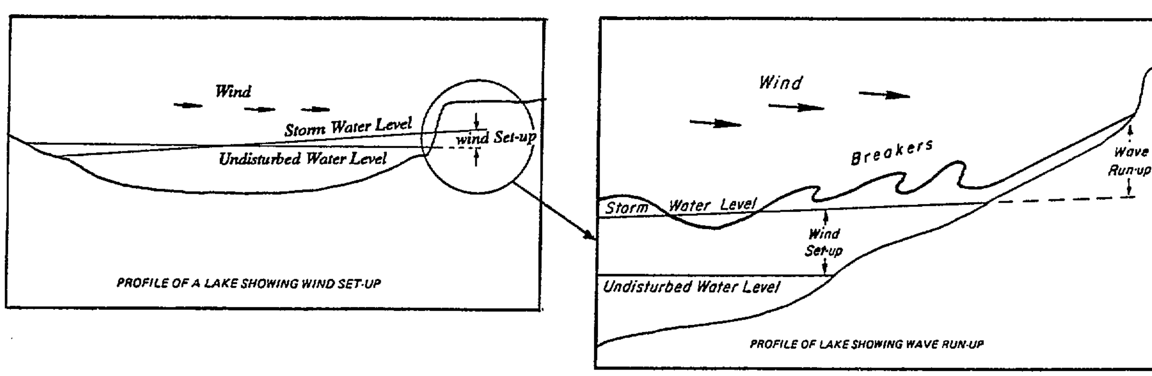
The "playa" or drainage lakes in the West and Southwest have no outlets or only limited outlets and are also subject to long-term fluctuations in water levels. Sinkhole lakes in Florida and throughout the Southeast also exhibit the characteristics of closed basin lakes. Flooding can be a problem on the shorelines of oxbow lakes,[6] which are common in the floodplains of the Mississippi River, its tributaries and other southern rivers.

Flooding caused by fluctuating lake levels presents a different set of problems than riverine flooding. Riverine flooding is typically of short duration, lasting for a period of hours or days. While relatively short-duration flooding can also occur on lakes, flooding associated with closed-basin lakes or lakes with inadequate outlet channels may persist for years.

TYPES AND CAUSES OF LAKE LEVEL FLUCTUATIONS

Lake level fluctuations can be caused by both natural and man-induced events. Natural factors influencing lake levels include precipitation, evaporation, upland runoff, ground water conditions, ice, aquatic growth, meteorological disturbances, and long term climatic trends. Man-induced factors influencing lake levels include dredging activities, diversions, consumptive water use, and regulation by structural works.

The most dramatic short-term changes in water levels are caused by strong winds and by sharp differences in barometric pressure. These fluctuations usually last less than a day and do not cause any changes in the total volume of lake water. The phenomena of surface tilt or wind set-up is illustrated on Figure 1-12.



Source: U.S. Army Corps of Engineers, Detroit District. Great Lakes Water Levels Facts. Detroit, Michigan: U.S. Army Corps of Engineers, 1987.

Figure 1-12. Storm Effects on Lake Levels.

[6] Oxbow lakes are closed-off channel segments left behind when the main channel of a meandering river cuts through the land and creates a new channel.

Seasonal lake level fluctuations are associated with the hydrologic cycle. In the early spring, snowmelt, heavier rains and reduced evaporation over a drainage basin typically cause lake water levels to rise from winter lows. This trend continues until peak levels are reached in the summer. As the summer progresses, runoff and ground water flows reach their lowest values and steadier winds and drier air increase evaporation. As a result, water supplied to the lake becomes less than the outflow, and the water level begins a downward trend, reaching the lowest levels during winter.

Long-term fluctuations in lake levels result when water supply conditions in a drainage basin become persistently low or high. These conditions can be caused by such factors as long-term climatic changes. The intervals between periods of high and low water and the lengths of such periods vary widely and erratically, and extreme lake levels are likely to persist even after the factors that caused them have changed. Long-term fluctuations in lake levels are particularly significant in the Great Lakes Basin.

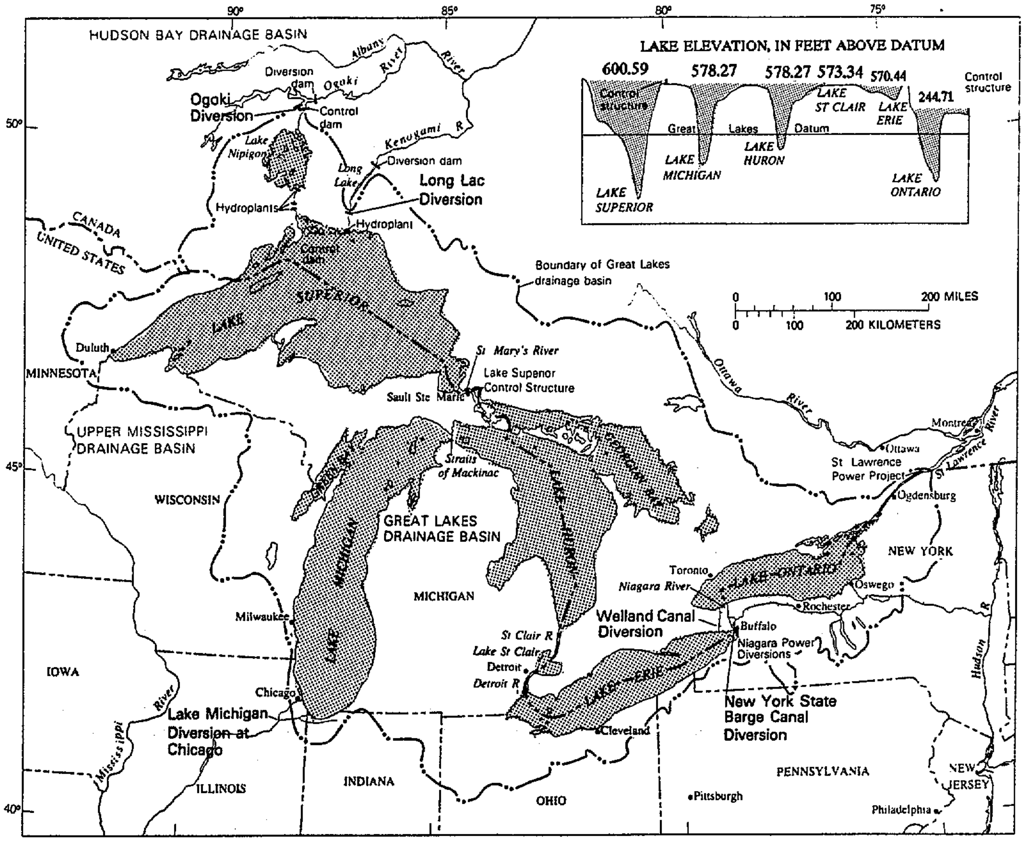
WATER LEVEL FLUCTUATIONS IN THE GREAT LAKES SYSTEM

The five Great Lakes (Superior, Michigan, Huron, Erie and Ontario) and their connecting waterways (see Figure 1-13), make up the largest fresh water lake system in the world, with a total water surface area of 95,000 square miles (Great Lakes Commission, 1986). Despite the natural drainage through the lake system, the Great Lakes are considered a closed-basin system because of the lakes' limited outflow capacities relative to the size of the basin (Federal Emergency Management Agency, 1986).

Fluctuations in Great Lakes water levels have occurred continually since the modern Great Lakes were formed some five to six thousand years ago and after the last ice age ended some 10,000 years ago (Hough, 1968). Yearly fluctuations on the average account for changes of about 12 to 18 inches, with lows normally occurring in January or February and highs in June through September (Great Lakes Commission, 1986). Longer-term fluctuations in water levels have been measured at over six feet from record lows to record highs. Since modern lake level measurements began in 1860, the Great Lakes have experienced distinct periods of high and low water levels. High water periods have occurred in the late 1920s, mid-1940s, early 1950s, early 1970s and mid-1980s (Federal Emergency Management Agency, 1987). Table 1-5 shows surface elevation data for the Great Lakes in this century (U.S. Army Corps of Engineers, 1987).

The water level in each of the Great Lakes is dependent on the hydrologic water balance — the balance between the amount of water entering the lake (from precipitation, runoff, snowmelt, inflow from connecting channels, diversions of water into the lake basin and ground-water inflow) and the amount of water lost (through evaporation, ground-water outflow, consumptive uses, diversions out of the lakes and flow through surface outlets).

The large size of the Great Lakes and the limited discharge capacities of their outlets cause extremely high or low lake levels to persist for a long period of time. Much of the shoreline of the lakes is highly erodible, and shore erosion and flooding have caused significant damage, especially during high water periods. Shoreline property damages have increased with each high water period because of the increased development of unprotected shorelines, rising shorefront property values and record high water levels.



Note: Elevations are in feet and are referenced to International Great Lakes Datum 1955. Zero Great Lakes Datum ranges from about 0.7 foot to about 2 feet below sea level.

Source: United States Geological Survey, National Water Summary 1985 - Hydrologic Events and Surface Water Resources. Water Supply Paper 2300. Washington, D.C.: U.S. Geological Survey Printing Office, 1986.

Figure 1-13. The Great Lakes System Showing Lake Profiles and Average Monthly Water-Level Elevations, 1900-1984.

It is extremely difficult to forecast future water levels in the Great Lakes Basin. Any attempt to do so requires accurate information on the various natural and human-induced factors affecting water levels. Future long-term fluctuations will occur; likely generating both extreme high and low conditions. It is also likely that serious flooding and erosion problems will occur again along the shorelines of the Great Lakes in the future.

Recently, the National Oceanic and Atmospheric Administration (NOAA) has conducted research into the impacts of the greenhouse effect on Great Lakes levels. NOAA predicted that higher air temperatures from the greenhouse effect "would also lead to such events as a shortened snow season in the Great Lakes basin with reduced snow melt runoff; increased evaporation of lake waters..." and other impacts. The result is that water levels in the Great Lakes over the next 75 to 100 years may drop an average of 2 to 4.5 feet (Anonymous, 1988).

Table 1-5. Changes in Water Levels in the Great Lakes, 1900-1986.

LAKE	LAKE SURFACE ELEVATION IN FEET* MONTHLY MEAN 1900-1986			RANGE (winter low to summer high monthly means)		
	Average	Maximum	Minimum	Average	Maximum	Minimum
Superior	600.61	602.24	598.23	1.2	2.1	0.4
Michigan-Huron	578.33	581.62	575.35	1.2	2.1	.4
St. Clair	573.40	576.69	569.86	1.7	3.3	.4
Erie	570.50	573.70	567.49	1.6	2.8	.9
Ontario	244.73	248.06	241.45	2.0	3.6	.7

* Water levels are referenced to International Great Lakes Datum 1955.

Source: Adapted from U.S. Army Corps of Engineers, Detroit District. Great Lakes Water Levels Facts. Detroit, Michigan: U.S. Army Corps of Engineers, 1987 (Table 2, p. 14).

LAKE LEVEL FLUCTUATIONS IN OTHER AREAS

Other lakes that have exhibited dramatic fluctuations in water levels include the Great Salt Lake in Utah, Lake Pulaski in Minnesota, Lake Elsinore, and the Salton Sea in California, Lake Malhuer in Oregon, and Devils Lake in North Dakota. Flooding problems of the Great Salt Lake and Lake Pulaski are illustrative of flooding problems on these other lakes.

Great Salt Lake, Utah

The Great Salt Lake can be described as a "terminal lake" because it receives inflow but has no outlet. Historical accounts of lake levels have been well documented since the mid-1800s and fluctuations between elevation 4,191.35 and elevation 4,211.85 feet above mean sea level (msl) have been recorded. After 1963, when the lake fell to the record low, new development and infrastructure facilities were established on the exposed lake bed. By 1975, however, the lake level had risen to 4,202 feet above msl, and in the fall of 1982 it began to rise even further in response to a series of storms (Federal Emergency Management Agency, 1987).

Between September 1982 and June 1983, the lake rose 5.2 feet — the greatest seasonal rise ever recorded — increasing the lake's surface area by 171,000 acres (267 square miles). In April 1983 a Presidential disaster was declared following severe storms, landslides and lake flooding. Damage estimates for total losses at the end of 1983 were approaching $500 million (Federal Emergency Management Agency, 1986).

Fed by unprecedented precipitation, the lake continued to rise steadily, reaching an all-time recorded high of 4,211.85 feet above sea level in June, 1986. It had risen 11 feet in 4 years, and the State of Utah was faced with the imminent loss of Interstate 80, railroads, wastewater treatment plants, and possibly the Salt Lake International Airport if the lake level continued to rise a few more feet (Federal Emergency Management Agency, 1986).

As a result, a number of flood control options were thoroughly studied and evaluated, including: diversion of water from the Bear River into the Snake River Basin in Idaho; dredging, diking, and pumping water from the Bear River; and pumping water into the west desert. The West Desert Pumping Project evolved as the quickest action that could be taken to provide the greatest flood control benefit at the most reasonable cost.

The pumping project was completed and the three giant pumps (3,300 cfs total capacity) began discharging water into the west desert in March 1987. Pumping, combined with two successive dry years, resulted in a lowering of the lake to an elevation of about 4,206.5 feet above msl by May of 1989. In July of 1989 the project was halted and the pumps "mothballed" (U.S. Water News, 1989).

Lake Pulaski, Minnesota

Lake Pulaski, located approximately 45 miles northwest of the Minneapolis-St. Paul metropolitan area, is landlocked with no outlet stream. Ground-water inflow feeds the lake but direct rainfall and runoff are the most significant contributors to elevated water levels and resulting flooding problems.

Following prolonged drought during the 1930s, the lake level remained low for an extended period of time and extensive lakeshore development took place, including year-round homes and seasonal cottages. Since the late 1960s, however, the water level has continued to rise steadily, inundating many exposed structures. Today much of the existing development surrounding the lake is at risk (Federal Emergency Management Agency, 1986).

SUMMARY AND CONCLUSIONS

Floodplains may be defined and identified in two basic ways — as natural geologic features or from a regulatory perspective. The one percent annual chance ("100-year") flood is the standard most commonly used for management and regulatory purposes in the United States. In part because of the different ways of defining and identifying floodplains, there is no definitive estimate of the total area of floodplains in the United States, or even of the area subject to a one percent annual chance flood. Existing estimates vary widely and cannot be readily compared because of differences in estimation techniques and definitions used.

Flooding concerns are not limited to the traditional riverine and coastal flooding situations. Also of concern are more unusual floods associated with alluvial fans, unstable channels, ice jams, mudflows and other types of ground failure, as well as fluctuating lake levels and areas "protected" by structural control works in both riverine and coastal areas. Flooding in areas outside delineated floodplains caused by inadequate surface drainage and high ground water levels is also of concern.

CHAPTER 2:

FLOODPLAIN RESOURCES AND VALUES

Floodplains are an integral part of river systems. Floodplains in their natural state provide for cleansing of pollutants and floodwater storage, as well as recreation. Alteration or development of the floodplain eliminates or degrades these values.

President's Commission on Americans Outdoors, 1987

Many of the Nation's most prominent landscape characteristics, including many of our most valuable natural and cultural resources, are associated with floodplains. These resources include wetlands, fertile soils, rare and endangered plants and animals, and sites of archaeologic and historic significance. Floodplains have been shaped, and continue to be shaped, by dynamic physical and biological processes driven by climate, the hydrologic cycle, erosion and deposition, extreme natural events, and other forces. The movement of water through ground and surface waters, floodplains, wetlands and watersheds is perhaps the greatest indicator of the interaction of natural processes in the environment.

These natural processes influence human activities and are, in turn, affected by our activities. They represent important natural functions and values and provide both opportunities and limitations for particular uses and activities. Traditionally, while much attention has been focused on the hazards associated with flooding and floodplains, less attention has been directed toward the natural and cultural values of floodplains or to evaluation of the full social and economic returns from floodplain use. In recent years, the natural values associated with floodplains — particularly wetlands — have been the subject of increased scientific study and management.

Surface water, ground water, floodplains, wetlands and other features do not function as separate and isolated components of the watershed, but rather as a single, integrated natural system. Disruption of any one part of this system can have long-term and far reaching consequences on the functioning of the entire system. In the past, lack of understanding of the overall natural system and its component processes contributed to significant alteration of the natural functions of floodplains, and in many cases to the degradation and destruction of these resources.

Floodplain resources, including wetlands and agricultural lands, are experiencing increasing pressure for use and development — for highways, for residential and commercial building sites, and for other urban uses. In response to these development pressures, knowledge and information regarding the natural resources, processes and values of floodplains can contribute to assessments of the ecological, economic and social impacts of further floodplain development. This knowledge and information can help to protect and better utilize the benefits and values these resources provide. Improved knowledge and information about the natural values of floodplains can be used to differentiate between lands that should remain in their natural condition, lands that can accommodate certain uses but not others, and lands that are most suitable for development.

The natural and cultural values associated with floodplain resources can be categorized in a variety of ways. Floodplain values can be thought of in terms of environmental quality values such as fish and wildlife habitat and water quality. They can also be thought of in terms of socioeconomic values, which are more easily understood by some because these values provide either dollar savings (related to flood and storm damage protection, for example) or financial profit (related to increased production from floodplain use).

A Unified National Program for Floodplain Management divides riverine and coastal floodplain resources into: 1) water resources; 2) living resources (habitat); and 3) cultural resources (Federal Emergency Management Agency, 1986). Figure 2-1 provides a listing of specific resources associated with each category. The division between these three categories of resources — particularly between water resources and living resources — is somewhat arbitrary. These resources are closely related and interwoven, and are often of a synergistic nature. They are described on the pages that follow.

Not all floodplains contain the same natural resources, and efforts to protect the natural values of floodplains have not always given equal weight and attention to all of the values. While categories of values, like categories of resources, are useful to keep in mind for discussion purposes, the values of floodplain resources are closely interrelated. Information relating to the extent of these values seldom fits neatly into specific categories.

Much work in recent years has been directed toward assessing wetland functions, resources and values, and has resulted in tabulations of wetland acreage and other statistics pertaining to the extent and quality of the Nation's wetland resources. Because most wetlands are located within floodplains, these wetland statistics can be usefully applied to floodplains. Although some attention has been directed toward quantitative assessments of other resources and values associated with floodplains, the floodplain component has seldom been separately quantified. As a result, statistical data comparable to that available for wetlands has yet to be developed for other floodplain natural and cultural resources.

Wetland research and other recognized sources of information have been used to compile data on the Nation's wetlands and riparian systems. Historical data on the extent of wetlands and riparian systems located within floodplains, however, do not exist. Surveys underway by the U.S. Fish and Wildlife Service (FWS), Soil Conservation Service (SCS), and others will provide a better definition of wetland location, history, and resource functions, including the proportion of wetlands and related habitat values located in floodplains. Data from these surveys were not available at the time of completion of the *Assessment Report*. Numerous small wetlands located in upland areas such as agricultural fields or forests are included in wetland resource totals but are distinctly outside of floodplain borders.

The economic value of various floodplain natural resources has not been well established, although considerable research regarding the economic value of wetlands has been conducted for many years. Table 2-1 presents an estimated dollar value per acre for several wetland functions (Heimlich, 1986).

NATURAL AND CULTURAL RESOURCES OF FLOODPLAINS

WATER RESOURCES

Natural Flood and Erosion Control:
- Reduce flood velocities
- Reduce flood peaks
- Reduce wind and wave impacts
- Stabilize soils

Maintain Groundwater Supply and Balance:
- Promote infiltration and aquifer recharge
- Reduce frequency and duration of low flows; i.e. increase/enhance base flow

Water Quality Maintenance:
- Reduce sediment loads
- Filter nutrients and impurities
- Process organic and chemical wastes
- Moderate temperature of water
- Reduce sediment loads

LIVING RESOURCES

Support Flora:
- Maintain high biological productivity of floodplain and wetland vegetation
- Maintain productivity of natural forests
- Maintain natural crops
- Maintain natural genetic diversity

Provide Fish and Wildlife Habitat:
- Maintain breeding and feeding grounds
- Create and enhance waterfowl habitat
- Protect habitat for rare and endangered species

CULTURAL RESOURCES

Maintain Harvest of Natural and Agricultural Products:
- Create and enhance agricultural lands
- Provide areas for cultivation of fish and shellfish
- Protect silvaculture
- Provide harvest of fur resources

Provide Recreation Opportunities:
- Provide areas for active and consumptive uses
- Provide areas for passive activities
- Provide open space values
- Provide aesthetic values

Provide Scientific Study and Outdoor Education Areas:
- Provide opportunities for ecological studies
- Provide historical and archaeological sites

Source: Adapted from U.S. Water Resources Council. A Unified National Program for Floodplain Management. Washington, D.C.: U.S. Water Resources Council, 1979.

Figure 2-1. Summary of Floodplain Natural and Cultural Resources.

Table 2-1. Estimated Wetland Values per Acre, from Recent Studies.

FUNCTION	SITE AND SOURCE	VALUE PER ACRE (1984 Dollars)
Aquaculture	Virginia tidal marsh	872-2,241
Fish Production	Virginia tidal marsh	269
Life-support	Virginia tidal marsh	10,333
Waste assimilation	Virginia tidal marsh	6,225
Sediment accretion	Alcovy River, GA	3
Timber production	Alcovy River, GA	1,605
Water quality enhancement	Alcovy River, GA	1,108
Ecological functions	Michigan coastal marshes	4,472
Fish and wildlife	Michigan coastal marshes	843
Flood control	Charles River, MA	362
Fish, wildlife and recreation	Charles River, MA	38

Source: Heimlich, Ralph E. and Linda L. Langer. Wetland Conversion and Farm Products. Agricultural Economic Report No. 551. Natural Resource Economics Division, Economic Research Service, U.S. Department of Agriculture. 1986.

WATER RESOURCES

Rivers are the "life blood" of our Nation and great biological systems supporting diverse forms of life. Throughout our history, they have been highways for exploration, migration, and commerce and have been used both as sources of water supply and as disposal systems for the byproducts of industrial society. There is hardly a major city not located on a river or at the mouth of a river. The contiguous 48 states contain 3.2 million miles of rivers, and another 365,000 miles are found in Alaska (U.S. Geological Survey, 1986). Most communities have at least one stream that helps to define local character and is an important source of community identity. As a number of cities and towns have demonstrated, our Nation's rivers and coastlines provide a common focus for urban growth and development.

Uses of water are characterized as in-stream uses and off-stream or diversion uses. Principal off-stream uses of surface water are for irrigation, industrial, municipal, and energy production purposes. For all but irrigation diversions, most of the water, following its use, is discharged to surface or ground waters and eventually returns to the stream system, usually with some aspect of its quality changed. The part of the diverted water that does not return to streams is consumed, mostly by vegetation, or enters the atmosphere through transpiration and evaporation. Diverted water is sometimes used in a drainage basin other than the one in which it originates, as water is typically transferred from regions with large supplies to others with smaller supplies or larger water demands. About forty percent of irrigation water withdrawn is ultimately returned to a stream or ground water (U.S. Department of Agriculture, 1989).

In-stream uses of water include navigation, fish and wildlife propagation, waste assimilation and transport, hydropower generation, agricultural and industrial uses, and recreational activities. These uses usually require some minimum flow rate and are largely competitive with diversion uses, which reduce the flow. For example, streamflow must not fall below some minimum rate if navigation is to continue, if fish habitat is to be preserved, or if waste loads are to be adequately assimilated. Flows needed for hydropower generation may change hourly, daily and seasonally. Optimum flows for recreational activities depend on the particular activity.

The surface water resources of the United States are extensively developed and managed for a multitude of uses, and surface water represents 77% of the Nation's total freshwater withdrawals (President's Commission of Americans Outdoors, 1987).

Total annual renewable water supply for the conterminous United States is about 1,380 billion gallons per day. Of this total, only about 8% or 117 billion gallons per day is consumed or not available for immediate reuse downstream. The spatial and temporal distribution of this water, however, is very uneven. In the New England water resources region, for example, less than 1% of the annual renewable water supply is consumed. In contrast, nearly the entire annual supply is consumed in the Colorado River basin (U.S. Geological Survey, 1986).

Increasing water demands have led to competition and conflicts between users in some areas. Throughout this century our national consumption of water has increased. The fastest growing uses have been for public water supplies (covering most residential and commercial uses) and for generating electricity. The largest single use is for irrigation, which currently accounts for 81% of all water consumption in the United States. Even though the total off-stream withdrawals of surface water more than doubled from 1950 to 1980, withdrawals still remained less than 21% of the renewable supply in 1980 (U.S. Geological Survey, 1986).

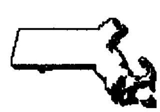
NATURAL FLOOD AND EROSION CONTROL

Natural floodplain systems can serve to reduce or avoid the environmental and economic costs associated with structural flood control works. The principal natural flood control values provided by floodplains and wetlands are:

- Reduction of flood velocities
- Reduction of flood peaks
- Reduction of wind and wave impacts

The physical characteristics of riverine and coastal floodplains affect flood flows and, except in steep narrow valleys and in the presence of coastal bluffs and escarpments, typically provide space for the dispersal and temporary storage of flood waters. This dispersal and storage function can serve to reduce peak flood flows and velocities and the potential flood damage impacts to people, resources and property. Flood storage is particularly important in urbanizing areas where even small floods resulting from a 5- or 10-year storm can cause severe flood damage. The flood storage effectiveness of a particular floodplain area depends on its size and hydrologic character, flooding characteristics, the distribution of streams or rivers in the watershed, vegetation and ground cover, and the location of development. One acre of a floodplain can hold 326,000 gallons of water if flooded to a depth of one foot.

Wetlands provide particularly valuable flood control functions. In their natural condition, most wetlands serve to temporarily store flood waters. This flood storage function helps to slow the velocity of water and typically to lower wave heights, thereby reducing the water's erosive potential. Wetlands slow the flow of water, store it for some time and slowly release stored waters downstream. In this manner flood peaks of tributary streams tend to be desynchronized and flood waters may not all reach the mainstream water course at the same time.



In the early 1970s the Corps of Engineers (Corps), New England Division, considered various alternatives to providing flood protection in the lower Charles River watershed near Boston, Massachusetts, including structural measures and perpetual wetlands protection. The Corps considered that wetlands protection through a "natural valley storage plan" was the least cost solution to the flooding problem. In 1983 wetland acquisition for flood protection purposes was completed in the Charles River Basin (Tiner, 1984).

Wetland vegetation can reduce shoreline erosion in several ways, including: 1) binding the soil with its root systems; 2) dampening waves through friction; and 3) reducing current velocity through friction. Trees help stabilize river banks as root systems bind the soil and trunks and branches slow the flow of flooding waters. The banks of some rivers have not been eroded for 100 to 200 years due to the presence of trees. While most wetland plants require calm or sheltered water for establishment, once established, this vegetation provides an important erosion control function. Wetland vegetation has been successfully planted to reduce erosion along U.S. waters (Dunne, 1978). Isolated wetlands such as the prairie potholes of the north-central United States also have important roles in storing flood waters as well as providing essential habitat for wildlife.

A study of the Devils Lake Basin in North Dakota revealed that natural, shallow depressions within the basin stored about 72 percent of the total runoff volume from a 2-year frequency storm and about 41 percent of the total runoff volume from a "100-year" (one percent) frequency storm (Ludden, 1983).

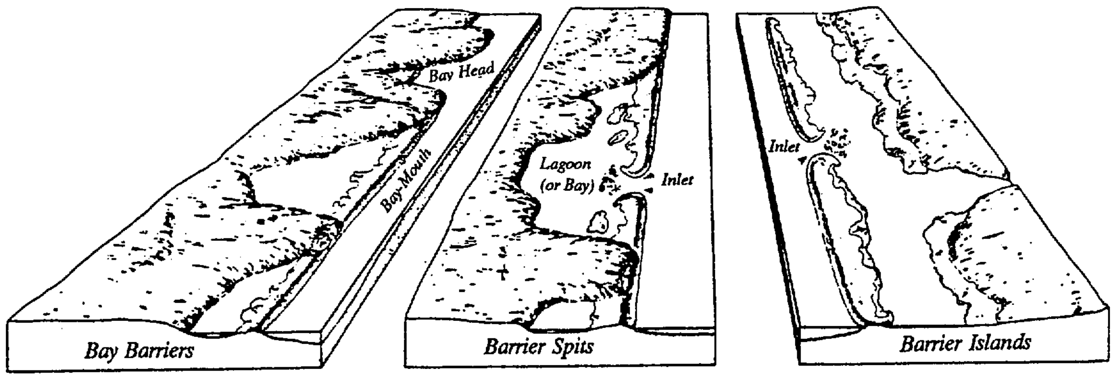
Coastal floodplains, in addition to flood storage and conveyance functions, can also serve to reduce wave impacts that may cause severe damage for distances as far as thousands of feet inland, depending on topography, vegetation and manmade or natural barriers. Beaches, sand bars, dunes, and wetlands act as natural barriers to dissipate waves and protect backlying areas from flooding and erosion.

Coastal barriers — elongated, offshore formations of sand and other unconsolidated sediments lying generally parallel to mainland coastlines — protect large portions of our mainland coastal area against severe storms and the surge and wave impacts that can accompany these storms. The term "barrier" reflects the protective aspect of these formations that serve to protect landward features such as bays, wetlands, estuaries and the mainland shoreline from the direct effects of high water, waves and currents caused by both "normal" conditions and by hurricanes, northeasters and other severe coastal storms.

The basic types of coastal barriers are depicted on Figure 2-2 and include bay barriers (connected to headlands on both ends), barrier spits (connected on one end), and barrier islands (bounded on each side by inlets without attachment to the mainland). In the United States, coastal barriers are found along the Atlantic and Pacific coasts as well as along the Gulf coast and Great Lakes shorelines. These barriers are most extensive and well developed along the Atlantic and Gulf coasts, where they make up one of the longest and most well defined coastal barrier systems in the world. Eighteen states along the Atlantic and Gulf coasts are fronted by nearly 300 coastal barriers ranging from small isolated shoals to long island chains (Leatherman, 1980). Figure 2-3 shows the distribution of these barriers.

These natural coastal barriers form several lines of defense against waves and erosion. Offshore and nearshore bars are the first line of defense, absorbing much of a wave's energy and causing it to break and weaken even though it may travel some distance inland. Dunes lying behind the beach are the second line of defense against storm waves, although a severe storm may destroy the dunes. In addition to acting as buffers to waves and erosion, dunes also partially protect against hurricane winds.

Vegetation on the barriers and coastal wetlands are a third line of defense, particularly in estuaries and behind barrier islands. Mangrove swamps are especially effective in this regard. Vegetated wetlands form in backlying areas that are subject only to infrequent storms such as the one percent annual chance event. When such events occur, wetland vegetation causes waves to dampen and break, dissipating much of their energy. Other coastal wetlands and forested wetlands along lakes and large rivers may function similarly.



Source: Leatherman, Stephen. Barrier Island Handbook. College Park, Maryland: University of Maryland, 1980.

Figure 2-2. Basic Types of Coastal Barriers.

WATER QUALITY MAINTENANCE

Natural floodplain systems can serve to reduce or avoid the environmental and economic costs associated with waste water treatment and water quality maintenance. Floodplains also provide important natural functions related to protecting the physical, biological and chemical integrity of water. These functions include:

- Reducing sediment loads
- Processing chemical and organic wastes
- Reducing nutrients

Floodplains buffer rivers, streams, lakes and estuaries from upland sources of pollution. An undisturbed, vegetated floodplain can filter surface runoff and capture sediment loads. Wetlands provide particularly important filtering functions because of their location between land and water. Floodplain wetlands can thus intercept runoff from land before it reaches the water and help filter nutrients, wastes and sediment from flooding water.

Floodplain vegetation reduces the velocity of sediment-laden flood water and results in deposition on overbank areas rather than in lakes, reservoirs and streams. Without floodplain vegetation, runoff flows quickly over the surface of a barren floodplain, and is capable of carrying large amounts of sediment and debris as well as pathogens and toxic substances to the main water body.

Wetlands play a valuable role in reducing the turbidity of flooding waters, an important function with regard to supporting aquatic life and reducing siltation of ports, harbors, rivers and reservoirs. Removal of sediment load is also valuable because sediments often transport absorbed and adsorbed nutrients, pesticides, heavy metals and other toxins that pollute water resources. Wetlands have been proven to be good filters of nutrients as well as heavy metal loads found in dredged material disposal effluent.

STATE	NUMBER OF BARRIER ISLANDS	TOTAL ACREAGE
Alabama	5	28,200
Connecticut	14	2,362
Delaware	2	10,100
Florida	80	467,710
Georgia	15	165,600
Louisiana	18	41,120
Maine	9	2,640
Maryland	2	14,300
Massachusetts	27	37,600
Mississippi	5	9,500
New Hampshire	2	1,100
New Jersey	10	48,000
New York	15	30,310
North Carolina	23	146,400
Rhode Island	6	3,660
South Carolina	35	144,150
Texas	16	383,500
Virginia	11	68,900
18 STATES	295	1,605,152

Source: Leatherman, Stephen. Barrier Island Handbook. College Park, Maryland: University of Maryland, 1980.

Figure 2-3. Representative Coastal Barriers.

Wetlands have an excellent capacity for removing water pollutants, and certain types of wetlands are specifically used to contribute to the processing of domestic waste waters. Wetlands remove nutrients from flood waters, especially nitrogen and phosphorous needed for plant growth, thereby maintaining wetland productivity and helping prevent eutrophication or over-enrichment of surface waters. Studies of heavily polluted waters flowing through Tinicum Marsh in Pennsylvania have revealed significant reductions in biological oxygen demand, phosphorous and nitrogen within three to five hours (Kusler, 1982).

A variety of studies have addressed the use of wetlands and floodplains for tertiary treatment of domestic and industrial wastes and stormwater runoff. Bottomland forested wetlands along the Alcovy River in Georgia have been shown to filter impurities from flooding waters and the value of the 2,300 acre Alcovy River Swamp for water pollution control was estimated at $1 million a year (Horwitz, 1978).

Despite these known abilities to remove pollutants, the long term effects of pollutant loading to wetlands are not well understood. Dramatic changes in species composition, however, have been observed in wetlands receiving increasing pollutant levels and current research is directed to examining the effects of pollutant loading on wetlands. It is thought that pollutant loadings stress and degrade wetlands, ultimately reducing the ability of wetlands to retain pollutants (Meagher, 1988).

Other water quality functions provided by floodplains include the trapping of nutrients, chemicals and other materials migrating through floodplain soils and the degradation of these materials by bacteria (Federal Emergency Management Agency, 1986).

GROUND-WATER SUPPLY AND BALANCE

Subsurface conditions of undisturbed floodplains can facilitate the infiltration and storage of water. The slowing and dispersal of runoff and floodwater allows additional time for this water to infiltrate and recharge ground-water aquifers when there is available storage space. The slowing of runoff and floodwater can also provide water purification benefits as the water infiltrates into the aquifer. Water entering the ground-water system during periods of high flow can reduce, rather than contribute to, flood peaks. In addition, water can also flow from higher ground-water systems into lower surface waters during periods of low flow, so that the frequency and duration of extremely low flows may be reduced.

Floodplains and wetlands can increase ground-water infiltration for human use. Municipal and private water supply wells are often located in floodplain alluvial deposits, and floodplains and wetlands can represent an important source of water supply for human consumption. Most wetlands are areas of ground-water discharge, and some wetlands store water that is important for wildlife and may be used for irrigation and livestock watering during periods of drought.

The role of wetlands in ground-water recharge has been the subject of some debate and scientific study. The recharge potential of wetlands has been shown to vary according to numerous factors, including wetland type, geographic location, season, soil type, water table location and precipitation. Floodplain wetlands may contribute to ground-water recharge through overbank water storage.

LIVING RESOURCES AND HABITATS

Coastal and riverine floodplains provide habitat for many and diverse populations of plants and animals, as well as sources of energy and nutrients for organisms in adjacent and downstream ecosystems. The wetlands and riparian areas of our Nation's floodplains are among the most productive of ecosystems. Wetland plants are particularly efficient converters of solar energy. Through photosynthesis, plants use sunlight to connect inorganic substances into plant material (biomass) and produce oxygen as a by-product. This biomass serves as food for a multitude of fish and wildlife species, both aquatic and terrestrial. The major food value of wetland plants is achieved when the plants die and fragment to form detritus. About 50% of the endangered species in the United States require wetland habitat at some point in their life cycle (Meagher, 1988).

WETLANDS

Wetlands and floodplains are not synonymous, but wetlands are perhaps the most prominent and familiar of floodplain resources. Wetlands in the floodplain are readily identifiable by the presence of typical emergent vegetation — plants that are rooted in the soil but grow through the surface of the water — or by varying amounts of submerged and floating plant life. The depth, duration of flooding, chemistry and temperature of the water (and in coastal marshes, the reach of the tide) determine the types of plant life found in a given wetland. These physical and chemical features determine the types of vegetation and the wide array of other living resources such as fish, mollusks, birds, crustaceans, insects, worms, and tiny organisms that find food and shelter in the substrate and within the vegetation.

Due to the diversity of wetlands and the difficulty in delineating precise boundaries between dry and wet environments, there is no single definition of wetlands. Wetland definitions have been formed according to the specific needs of wetland regulators, waterfowl biologists, hydrologists, flood control and water quality engineers, and others concerned with wetland management.

One definition of wetlands that has been widely accepted as a national and international standard has been developed by the U.S. Fish and Wildlife Service (FWS):

> *Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: 1) at least periodically, the land supports predominantly hydrophytes (wetland vegetation); 2) the substrate is predominantly un-drained hydric soil; and 3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year* (Tiner, 1984).

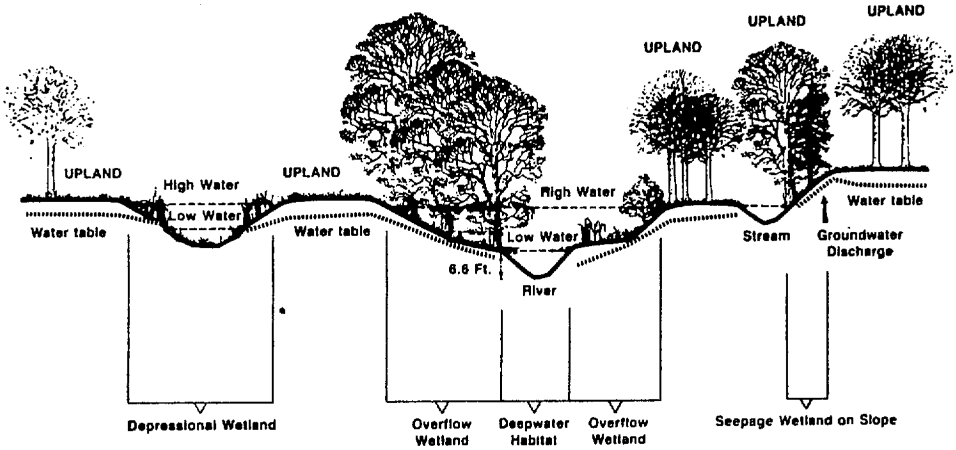
Included within these broad limits is a wide variety of lands that are continuously submerged or intermittently inundated by seasonal river flooding or normal tidal action. Figure 2-4 illustrates different areas where inland wetlands typically form, and Figure 2-5 illustrates areas of coastal wetland formation.

At least two other definitions of wetlands have been applied nationally. The U.S. Army Corps of Engineers (Corps) and the U.S. Environmental Protection Agency (EPA) use the following definition of wetlands in administering the Section 404 permitting program:

> *The term "wetlands" means those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas* (33 CFR, 328.3 (b)).

In 1985 Congress added a slightly different definition of wetlands as part of the "Swampbuster" provision of the Food Security Act of 1985 (P.L. 99-198):

> *...Land that has a predominance of hydric soil and that is inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions, except that this term does not include lands in Alaska identified as having a high potential for agricultural development and a predominance of permafrost soils.*

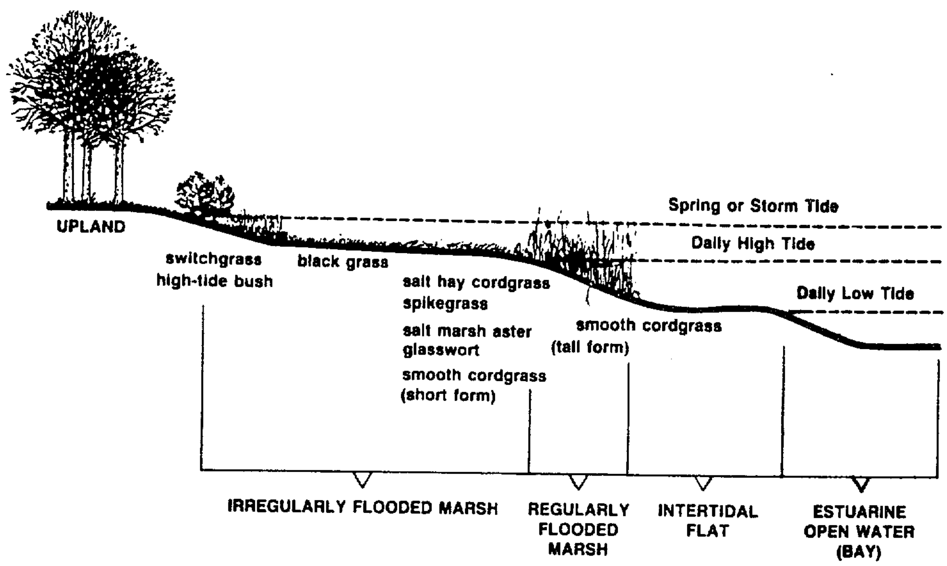


Source: Tiner, Jr., Ralph W. Wetlands of the United States: Current Status and Recent Trends. Newton Corner, Massachusetts: U.S. Fish and Wildlife Service, Habitat Resources, 1984.

Figure 2-4. Inland Wetlands.

In January 1989, the Corps, EPA, FWS, and the U.S. Soil Conservation Service (SCS) signed an interagency agreement to adopt a single consistent approach to determining which areas are wetlands under the jurisdiction of federal programs. A manual (*The Federal Manual for Identifying and Delineating Jurisdictional Wetlands*) detailing the technical procedures for wetland identification went into effect for Section 404 of the Clean Water Act on March 20, 1989. This new manual supersedes earlier EPA and Corps wetland delineation manuals. It should help assure consistency and repeatability in wetland jurisdiction decision-making, and, therefore, should result in less frequent interagency disagreements over the extent of wetlands at a site (U.S. Environmental Protection Agency, 1989).

Because of the different definitions of wetlands that have been used, determining the total amount of wetlands in the United States and their regional distribution is difficult. Several attempts have been made over the years to inventory wetlands. Mitsch reviewed several studies of wetland trends and concluded that "(1) Estimates of the area of wetlands in the United States vary widely, and (2) Most studies have indicated a rapid rate of wetland loss in the United States, at least prior to the mid-1970s" (Mitsch, 1986). A National Wetland Trends Study conducted for the FWS in the early 1980s estimated total wetlands in the contiguous 48 states at 108 million acres in the mid-1950s and at 99 million acres in the mid-1970s. Of the 99 million acres in the mid-1970s, only 5.2 million were estuarine wetlands and the remaining were inland wetlands. Another frequently cited estimate is that wetlands now cover a little more than 90 million acres or about 5% of the continental United States and 200 million acres or about 60% of Alaska (Office of Technology Assessment, 1984). A recent FWS study of wetlands status and trends estimated a total of 103 million acres of wetlands in the contiguous 48 states. Of this total, 52 million acres are considered commercial forested wetlands. (U.S. Fish and Wildlife Service, 1991.)



Source: Tiner, Jr., Ralph W. Wetlands of the United States: Current Status and Recent Trends. Newton Corner, Massachusetts: U.S. Fish and Wildlife Service, Habitat Resources, 1984.

Figure 2-5. Coastal Wetlands.

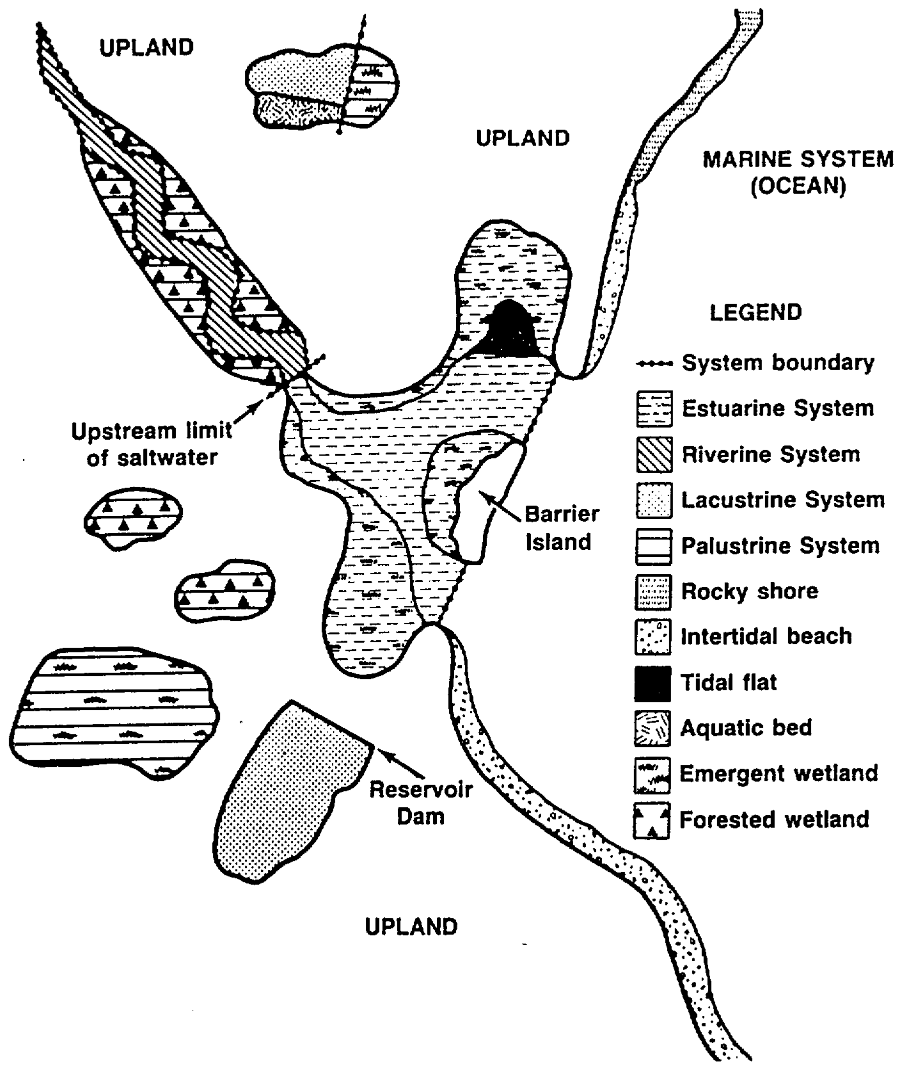
State by state estimates vary widely among surveys, with estimates differing by more than 100 percent for many states. Despite the variation among surveys, Florida and Louisiana consistently show the greatest wetland acreage in the lower 48 states. Wetland estimates for Alaska have ranged from 130 to 300 million acres, most of it wet tundra (Mitsch, 1986).

Although wetlands represent only a portion of overall floodplain acreage, essentially all coastal wetlands and most inland wetlands occur within floodplains. As a result, the values ascribed to wetlands can be considered, for most practical purposes, as floodplain values as well. (Wetlands along lakes and isolated wetlands, such as those in the Prairie Pothole region, are subject to periodic increases in ground or surface water levels that cause flooding, although these wetlands may not lie within traditionally defined floodplains.)

Wetland Types

Wetlands can be grouped according to ecologically similar characteristics. The Cowardin, et al., system developed for the FWS categorizes wetlands and deepwater habitats according to five ecological systems: 1) marine; 2) riverine; 3) lacustrine; 4) estuarine and 5) palustrine (Tiner, 1984). Figure 2-6 illustrates the relative location of these different types of wetlands.

Deepwater habitats are defined as permanently flooded areas having a depth of greater than two meters (6.6 feet). These areas are not classified as wetlands under the Cowardin, et al., system. The deepwater habitat of the marine system generally consists of the open ocean, with marine wetlands limited to intertidal areas like beaches, rocky shores and aquatic beds. The riverine system includes the main channels of rivers and their tributaries as well as nonpersistent emergent wetlands. The lacustrine system includes standing waterbodies like lakes, reservoirs and deep ponds, as well as aquatic beds and nonpersistent emergents.



Source: Tiner, Jr., Ralph W. Wetlands of the United States: Current Status and Recent Trends. Newton Corner, Massachusetts: U.S. Fish and Wildlife Service, Habitat Resources, 1984.

Figure 2-6. Major Wetland and Deepwater Habitat System.

Estuarine and palustrine wetlands are the best known wetland types. The estuarine system includes coastal wetlands such as salt and brackish tidal marshes, mangrove swamps, and intertidal flats as well as the deepwater habitats associated with bays, sounds and coastal rivers. Estuarine wetlands are divided into three major types: 1) emergent wetland; 2) intertidal flat; and 3) scrub-shrub wetland.

Palustrine wetlands, which account for roughly 90% of all wetlands in the United States, are inland wetlands consisting primarily of freshwater wetlands such as marshes, bogs and swamps, although inland salt and brackish marshes exist in arid and semiarid areas. (Salt marshes are found as far inland as Utah and the Dakotas, where soils with a high salt content predominate and evaporation rates are high.) Palustrine wetlands can also be classified according to three major types: 1) emergent; 2) scrub-shrub; and 3) forested wetland (Tiner, 1984).

RIPARIAN ECOSYSTEMS

Riparian floodplain ecosystems are distinct associations of soil, flora and fauna occurring along a river, stream or other body of water and dependent for survival upon high water tables and occasional flooding. Although riparian ecosystems have many of the same values as wetlands, several characteristics distinguish them from other ecosystems, including a high water table and linear form as a consequence of their proximity to rivers and streams. Riparian ecosystems are also marked by a high species density and diversity, and a high rate of interaction with upstream and downstream ecosystems (Mitsch, 1986). Riparian ecosystems encompass a broader range of moisture and soil conditions and a greater diversity of flora and fauna than wetlands (i.e., riparian systems typically include wetlands along with other types of habitat).

Although the ecosystem functions of riparian areas are not fully understood, these areas are generally more biologically diverse than surrounding uplands, with diversity most pronounced in arid regions and along the banks of large, perennial warmwater streams. The variety of flora within riparian systems is largely attributable to biotic and nutrient exchanges with aquatic and upland areas. The presence of water and periodic flooding, as well as an edge effect maximized by the long narrow shape of riparian communities, account for their floral and faunal diversity.

Estimates of total riparian habitat in the United States are as elusive as are estimates for floodplain area and wetlands. The 1982 National Resources Inventory (NRI) conducted by the Soil Conservation Service, estimated 16 million acres of riparian land along natural or manmade streams, canals, lakes, reservoirs and tidal shorelines of rural, nonfederal portions of the United States. (Soil Conservation Service, 1987). Other sources indicate that bottomland hardwood forests are the major types of riparian ecosystem found in the United States, covering large areas in the southeastern United States. It has been estimated that there are approximately 58 million acres of bottomland hardwood forest in the United States, of which slightly more than half is located in 12 southern states (Mitsch, 1986). Major areas of bottomland hardwood forests, however, have been altered as a result of draining and clearing for agricultural use and other purposes.

FISH AND WILDLIFE HABITAT

Due to the abundance of water and vegetation, floodplains provide wetland, riparian and other habitat (including shelter and food sources) for large and diverse populations of fish and wildlife species. Floodplain wetlands, for example, are major sources of food and breeding habitat for both saltwater and freshwater fisheries and for many types of wildlife. Floodplains are especially important and productive sources of energy and nutrients in large part because they contain the elements of both terrestrial and aquatic ecosystems. The fish and wildlife resources supported directly and indirectly by floodplains represent a renewable resource of great economic importance to the states and the Nation.

The variety of floodplains and associated wetlands across the country create habitat for many forms of fish and wildlife. Some animals spend their entire lives in floodplain wetlands while others use the wetlands primarily for reproduction and nursery grounds. Numerous fish and wildlife species depend on marshes and swamps for feeding or feed on organisms produced in wetlands, and many animals visit wetlands for drinking water. Wetlands are also crucial for the survival of numerous endangered species such as the American crocodile, the manatee, the whooping crane, and the Mississippi sandhill crane, as well as numerous species of plants.

Coastal barriers and associated wetlands and nearshore waters are especially important in maintaining the natural productivity of the coastal environment and provide invaluable habitat for fish and wildlife. The estuaries and bays protected by coastal barriers are among the most valuable and productive of all ecosystems.

Both inland and coastal wetlands are essential to maintaining important fish populations. Approximately two-thirds of the major commercial fish species in the United States depend on estuaries and salt marshes for nursery or spawning grounds (Horwitz, 1978). Coastal marshes along the Atlantic and Gulf coasts are most important in this regard. Coastal wetlands are also essential for the support of shellfish.

Freshwater fishes also find wetlands important for survival. In fact, most freshwater fishes can be considered wetland-dependent because: 1) many species feed in wetlands or upon wetland-produced food; 2) many fishes use wetlands as nursery grounds; and 3) almost all important recreational fishes spawn in the aquatic portions of wetlands. Wetland vegetation along rivers is important to fishes in many ways, including providing cover, shade for water temperature regulation, and food for aquatic insects which are eaten by fishes.

Floodplains and wetlands provide important habitat for waterfowl and other birds. Floodplain wetlands are crucial for the existence of many birds, ranging from waterfowl and shorebirds to songbirds. Some spend their entire lives in wetland environments, while others primarily use wetlands for nesting, feeding or resting. In addition to providing year-round habitats for resident birds, coastal and inland wetlands are especially important as breeding grounds, over-wintering areas and feeding grounds for migratory waterfowl and numerous other birds.

Salt marshes along the Atlantic coast are important feeding and stopover areas. Northern salt marshes are primary wintering grounds for black ducks in the Atlantic Flyway. Intertidal mudflats along all coasts are principal feeding grounds for migratory shorebirds, and freshwater coastal marshes also provide habitat for a variety of species. Wetlands along the Gulf coast provide nesting and feeding grounds for many species of waterfowl.

Inland wetlands are most noted for waterfowl production, although they also serve as important nesting, feeding and resting areas for other migrating birds. The prairie pothole region of the Dakotas is the principal breeding area for waterfowl in the United States. Mississippi River floodplains are major duck and geese resting and feeding grounds during fall and spring migrations.

Alaskan and other tundra wetlands are prime breeding grounds for most shorebirds. During droughts in the Prairie Pothole region, Alaska's wetlands are heavily used by North American waterfowl for nesting. Hawaii's wetlands are especially important to endangered birds.

Both coastal and inland wetlands also provide valuable habitat for furbearers, other small and large mammals and other forms of wildlife such as turtles, reptiles and amphibians. Wetland utilizing furbearers include muskrats, beavers, otter, mink and raccoon. Larger mammals such as black bears, white-tailed deer and caribou also find refuge and food in wetland areas (Greeson, 1979 and Mitsch, 1986).

Bottomland forests of the South are primary wintering grounds for North American waterfowl as well as important breeding areas for many species. Forested wetlands in the eastern half of the United States also provide important avian habitat. In the West, riparian forests along rivers are valuable bird nesting and migration stopover areas. Riparian habitat may be more important to migrating birds in arid regions than in more humid areas. The availability of food, water, cover and suitable north-south routing strongly influence migrants (Greeson, 1979 and Mitsch, 1986).

Healthy riparian communities provide community structure for raptors, safe passage corridors to water for mammals, habitat for amphibians, and cover and nutrients for fisheries. For example, riparian habitat in the Southwest provides wildlife with food resources and community structure. At elevations below 3,500 feet, this habitat provides lush strips of streamside vegetation interrupting desert landscapes. These linear communities provide habitat for up to 80% of western wildlife species, and riparian corridors are considered to be essential for maintaining healthy fish and wildlife populations in this region (Hunt, 1985). Cottonwood groves provide a high canopy and open understory essential to certain birds of prey for hunting, while mesquite bosques provide lower, denser vegetation ideal for colonial nesting by white-wing doves.

The multitude of wildlife species largely dependent upon the region's varied riparian habitats include grey squirrels, river otters, muskrats, summer tanagers, canyon frogs, tree frogs and dove tailed hawks. Arizona's native cottonwood-willow associations support higher densities and a greater diversity of breeding bird species than any other desert habitat type; two New Mexican river valleys alone support 16-17% of North America's breeding avifauna (Hunt, 1985).

The floodplains of the West are of extreme importance to a wide variety of plants and animals. Precisely because of the scarcity of water, the varied habitat in the narrow band between water and desert supports some of the most diverse communities of birds and mammals in the world (Johnson, 1985).

In southeastern Arizona, the San Pedro River and its adjoining riparian habitat have long been identified as being a nationally significant ecosystem. This river is the best remaining example of a major riparian ecosystem in the Southwest still largely unaffected by man. This nationally significant river and its adjoining vegetation provides nesting, migratory or wintering habitat for at least 20 raptor species and a total of approximately 210 species of birds. Additionally, a study recorded 78 species of mammals in the grasslands corridor between the riparian woodlands and the adjacent mountains. This represents the second-highest mammalian diversity recorded in the world (Spear, 1985).

CULTURAL RESOURCES

Under today's definition, "cultural resources" are limited to prehistoric and historic sites, archaeological resources, buildings, districts, structures, landscapes, objects, and any other material remains of past human life. The cultural resources of floodplains, however, as adapted from the 1979 version of *A Unified National Program for Floodplain Management*, are many and include resources associated with scientific and recreation/open space uses and the harvest of natural and cultivated products (agricultural, aquacultural and forestry uses) as well as historical/archaeological sites.

Cultural resources of floodplains are often in competition with floodplain natural resources and are frequently subject to flood hazards. Agricultural and recreational uses, for example, may result in loss of wetlands or riparian habitat.

HARVEST OF NATURAL AND AGRICULTURAL PRODUCTS

Inland floodplains are great sources of commercial timber. In the 48 contiguous states, an estimated 52 million acres of commercial forested wetlands exist, and much of the acreage is within floodplains. Most of these forests lie east of the Rockies. The standing value of southern wetland forests alone is $8 billion (Tiner, 1984). These southern forests have been harvested for over 200 years, and for the most part with relatively little degradation.

Floodplains also produce a variety of natural crops such as blueberries, cranberries and wild rice that do not depend on fertilizer. Coastal wetlands have historically been harvested for salt marsh hay, and wetland grasses are hayed in many places for winter livestock feed. Livestock may also graze directly in wetlands across the country.

Wetlands produce fish and wildlife for human use. Commercial fishermen and trappers make a living from these resources. From 1956 to 1975 about 60% of the United States commercial fisheries landings consisted of fish and shellfish that depend on wetlands. Two-thirds of the commercially important fish and shellfish harvested along the Atlantic coast and in the Gulf of Mexico depend on coastal estuaries and their wetlands for food sources, for spawning grounds, for nurseries for the young or for all these purposes. On the Pacific coast, almost half of the commercially important species are estuarine and wetland dependent. Freshwater wetlands provide a greater value of harvest per acre than estuarine wetlands. Several billion dollars a year are generated from wetland-dependent sport and commercial fisheries harvest (Tiner, 1984).

Floodplains along larger rivers are often prime agricultural lands because of their flat terrain, abundant water supplies and rich alluvial soils that are periodically replenished by flooding. Prime agricultural soils represent the highest level of agricultural productivity; they are uniquely suitable for intensive cultivation. Until the last decade or two, conversion of wetlands to agricultural production was considered a favorable practice, and cultivation of these areas was subject to few conservation-related constraints. Consequently, throughout most of United States history, floodplains have been heavily used for agriculture and wetlands (in and out of floodplains) have been drained for conversion to agricultural production. Agricultural lands, including those within floodplains and created by draining wetlands, are subject to increasing pressures for nonagricultural uses, and the short-term economic value of these lands for urban development is often higher than for agricultural purposes. Market values of farmlands do not reflect the long-term value or the irreplaceable nature of the floodplain soils.

RECREATIONAL AND OTHER RESOURCE FUNCTIONS

The recreational opportunities associated with floodplain resources range from water-oriented sports to hiking and camping, hunting and fishing and passive enjoyment of scenic resources. For many types of active recreational activities, such as fishing, hunting, boating and swimming, water is the focal point. For other activities such as hiking, camping and bird-watching, water is an important backdrop. Recreational use of rivers and streams is increasing rapidly as thousands of stretches of rivers, streams and local creeks provide recreational benefits. Most communities have at least one stream that does, or could, serve as a visual centerpiece for recreation opportunities (President's Commission on Americans Outdoors, 1987).

In many areas of the country, states and localities have acquired floodplains to serve as major recreation areas for fishing, hunting, bird watching, picnicking, hiking, jogging, swimming and boating. Floodplains can provide community open space resources and green belt areas for recreational use in urban environments. A 1978 study of 17 major cities by the Heritage Conservation and Recreation Service and the National Park Service revealed that floodplains are often the prime remaining park and recreation sites in major urban areas (Kusler, 1982). In addition, many communities have focused urban renewal and historical preservation and restoration projects on waterfront areas located in or adjacent to floodplains.

Waterfowl hunting is a major wetland activity and in 1980 5.3 million people spent $638 million hunting waterfowl and other migratory birds. Saltwater recreational fishing has increased dramatically over the past 20 years, with half of this catch represented by wetland-associated species (Tiner, 1984). Nearly all freshwater fishing is dependent on wetlands.

Nonconsumptive recreational activities include hiking, nature observation and photography, swimming, boating and ice-skating. Increasing numbers of Americans are enjoying river recreation. Across the Nation, free-flowing and scenic stretches of rivers are used for white water rafting. The coastal area provides aesthetic and cultural resources as well as numerous recreational opportunities that contribute to making these environments desirable places to live and visit.

Other cultural resources provided by floodplains include opportunities for scientific study and educational activities as well as less tangible aesthetic benefits. Many people simply enjoy the beauty and sounds of nature and spend their leisure time walking or boating in or near wetlands observing plant and animal life. Most of the Nation's earliest archaeological and historical sites are found in floodplain areas that can also provide unique opportunities for natural scientific study and research (Federal Emergency Management Agency, 1986).

COMMON THREATS TO RESOURCES

Each of the three categories of floodplain resources (water resources, living resources, and cultural resources) are threatened in various ways. The three basic types of floodplain water resources values are typically threatened by: 1) INCREASED RUNOFF associated with such activities as widespread clearing of vegetation, wetlands destruction, sand dune removal, paving, roofing, and other development actions; 2) BLOCKING OF RUNOFF AND INTERRUPTION OF GROUND-WATER MOVEMENT by various development actions; and 3) INCREASED POLLUTION. Increased runoff may cause increases in flood peaks, stream erosion and the sediment loading of receiving waters. Blocked runoff or interrupted ground-water flow can raise flood profiles, increase pollution and interfere with ground-water balances and the distribution of sediment. Fertilizers, chemical and petroleum spills, leached materials from waste disposal areas and other pollutants can degrade the surface and ground-water resources found in some floodplains. Lowering the ground-water elevation can significantly change other floodplain characteristics by causing changes in vegetation and vegetation patterns. These changes can be particularly dramatic in arid regions (Federal Emergency Management Agency, 1986).

Development and modification of the floodplain can affect living resources and habitat in many different ways. Increased sedimentation, for example, can bury food sources and spawning areas and pollution can poison living resources. Development activities can remove shelter and food sources and result in barriers to fish and wildlife movement. Erosion of coastal wetlands and wetland filling for development purposes can eliminate large areas of productive habitat.

The cultural resources of floodplains, like the water and living resources, can be significantly affected by floodplain modifications, use and development practices. As a result, accelerated and blocked runoff, interrupted ground-water flow and increased pollution can result. Poor agricultural and forestry practices can be just as destructive of natural floodplain resources as poorly planned urban development (Federal Emergency Management Agency, 1986).

SUMMARY AND CONCLUSIONS

Historically, floods and floodplains were thought of in terms of the accommodation of human settlement and the consequences of such settlement. Only in recent years have the natural and cultural resources of floodplains been recognized as valuable in their own right. During the last twenty years or so, the combined effects of research and legislation have heightened awareness of these natural and cultural resources, including: 1) water resource functions such as natural flood and erosion control, water quality maintenance, and maintenance of ground-water supply and balance; 2) living resource functions such as support for a wide variety of flora, and provision of fish and wildlife habitat; and 3) cultural resource functions such as maintaining a harvest of natural products, providing recreation opportunities, and providing scientific study and outdoor education areas.

Most of these natural and cultural resources are not associated exclusively with floodplains — the floodplain resources are a specialized and important component of a larger set of resources and values. While the values of these resources are now well recognized and most processes reasonably well understood, only limited information is available that quantifies the value of these natural and cultural floodplain resources. Even wetlands, which in many areas are nearly conterminous with floodplains and which have been studied extensively, are not well quantified. Estimates of the total amount of wetlands in the United States and state by state estimates vary widely depending upon when the estimate was made, what definition of wetlands was used, and the survey techniques that were employed.

All of the natural and cultural resources and functions of floodplains are subject to many threats, among the most significant of which are threats related to human use and development. Only a limited type and amount of human uses are compatible with most floodplain resources and natural functions.

CHAPTER 3:

FLOODPLAIN DEVELOPMENT AND LOSSES

...[A]s population has increased, men have not only failed to devise means for suppressing or for escaping this evil [the flood], but have, with singular short-sightedness, rushed into its chosen paths.

W J McGee, "The Flood Plains of Rivers," *Forum*, XI, 1891

From the times of the earliest European settlement of this country, locations adjacent to water bodies have been popular, and often essential, for development. Many of these locations, of course, lie within the natural floodplain of rivers, streams, lakes and coastal areas. Archeological evidence indicates that native Americans also used floodplain locations. Typically, these early floodplain settlements were often temporary, could be quickly evacuated, and did not suffer great losses when the sites were flooded. In contrast, the permanent location of homes, businesses, infrastructure and agricultural activities within floodplains in contemporary times annually results in billions of dollars of damages when floodwaters reclaim these lands.

Throughout this Nation's history, the prevailing view has been that man could (and should) modify the natural environment to meet human needs. Individuals and governments have enthusiastically engaged in the construction of dams and reservoirs, levees, floodwalls and stream channelization projects in efforts to prevent or limit damages to development that was either knowingly or inadvertently placed within the floodplain. Thousands of water supply projects — particularly in the arid west, but occurring throughout the Nation — have dramatically changed natural functions of riparian areas. Millions of acres of inland and tidal wetlands have been filled or drained, causing loss of natural flood storage areas, lowered capacity for filtration of pollutants and ground-water recharge, and reduction or elimination of some wildlife species.

This large-scale development and modification of floodplains has resulted in a major increase in the land area of the United States that may be economically developed and used, but at a high price extracted annually in loss of life, personal suffering and inconvenience, economic losses, and loss of natural and cultural resources.

Even though floods annually cause greater economic losses than any other type of natural disaster (with the exception of drought losses during certain years or long-term periods), accurate figures on the actual extent of annual flood losses remain unavailable. In addition, as described in Chapter 1, the actual amount of United States land in floodplains has not been clearly determined, nor has the amount of property and other economic investments at risk to flooding been firmly established.

FLOODPLAIN DEVELOPMENT

Several studies have attempted to assess the extent of floodplain development in the United States. When viewed collectively, the resulting estimates aid in understanding the magnitude of a significant problem. There are, however, no definitive statistics pertaining to the amount of development at risk to flooding in the United States.

EXTENT OF FLOODPLAIN DEVELOPMENT IN THE UNITED STATES

The best available estimates of floodplain land in the United States have ranged from approximately seven percent of the entire land area of the United States to 14 percent of the nonfederal, rural land (excluding Alaska).[1] The largest floodplain areas are in the southern part of the country, but the most populous are in the North Atlantic and Great Lakes regions and California. A 1977 U.S. Water Resources Council (WRC) assessment estimated that 3.5 to 5.5 million acres of floodplain land are in urban use. The urban and built-up areas were judged to include more than 6,000 communities with populations of 2,500 or more (U.S. Water Resources Council, 1977).

The central portions of many cities — both large and small — consist of floodplain lands. In a 1974 review of 26 cities ranging in size from 50,000 to 7 million, the U.S. Geological Survey (USGS) found that, on the average, 53% of the floodplains in those cities was developed (U.S. Geological Survey, 1974). Other surveys conducted during the 1970s suggested that urban growth within floodplain areas was between 1.5% and 2.5% per year, roughly twice the rate of population growth for the country as a whole at that time (White, 1975).

Other recent studies have attempted to more accurately assess the extent of floodplain development. The Federal Emergency Management Agency (FEMA) has identified flood hazards in 20,493 communities throughout the United States, including Puerto Rico, U.S. Virgin Islands, Guam and the Northern Marianas (Federal Emergency Management Agency, 1989), but not all of these communities have significant development within the floodplain or have strong potential for growth in the near future. A 1978 report (Sheaffer, 1978) estimated that 7.9 percent (or 4.5 million housing units) of the 57.3 million occupied housing units in the United States were in special flood hazard areas. In addition, 325,000 nonresidential units were estimated to be in flood hazard areas.

A refinement of a 1987 study conducted for FEMA (Donnelley, 1987) examined 17,466 floodprone communities to estimate the property at risk. This study found that the floodplain areas in these communities occupied a total of about 146,600 square miles (93.8 million acres) and, as shown in Table 3-1, included approximately 9.6 million households at risk and $390 billion in property at risk. Based on a composite risk score developed for the study, Florida ranked as the state with highest risk, followed by California, Texas, Louisiana and New Jersey.

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1 See Chapter 1 for a more detailed description of floodplain area in the United States.

Table 3-1. FEMA Estimate of Property at Risk from Flooding.

STATE	FLOODPLAIN AREA IN SQUARE MILES	FLOODPLAIN HOUSEHOLDS 1987	VALUE OF FLOODPLAIN HOUSEHOLDS 1987
Alabama	5,237	236,766	7,576,674,844
Alaska	731	4,750	291,785,955
Arizona	2,618	98,052	3,267,311,956
Arkansas	9,206	228,252	5,981,276,727
California	6,831	681,438	45,706,298,363
Colorado	1,587	77,442	3,738,076,339
Connecticut	285	94,470	5,601,143,436
Delaware	199	31,949	1,291,132,454
Dist. Columbia	1	16,657	902,183,269
Florida	10,034	971,323	46,189,074,261
Georgia	3,548	207,293	7,225,068,115
Hawaii	59	7,572	672,651,254
Idaho	548	15,060	602,411,309
Illinois	4,559	337,642	15,911,660,586
Indiana	2,627	238,576	8,785,544,502
Iowa	2,288	114,569	4,384,581,121
Kansas	3,790	115,197	3,942,079,035
Kentucky	2,120	112,743	3,528,138,998
Louisiana	12,180	661,839	26,876,649,178
Maine	906	33,459	1,071,604,991
Maryland	676	113,343	5,383,860,885
Massachusetts	547	163,182	7,440,748,038
Michigan	657	145,384	6,673,390,073
Minnesota	2,778	98,493	4,860,810,206
Mississippi	8,217	207,413	5,176,305,887
Missouri	5,143	216,453	7,991,205,800
Montana	1,072	13,392	443,321,171
Nebraska	3,079	238,846	9,316,174,544
Nevada	1,880	27,452	1,579,815,755
New Hampshire	239	19,712	829,920,022
New Jersey	958	452,579	20,961,050,445
New Mexico	1,868	74,518	3,314,009,278
New York	1,557	466,947	11,317,224,372
North Carolina	5,265	278,863	8,694,853,746
North Dakota	1,432	84,780	3,515,958,504
Ohio	1,907	277,989	11,058,489,912
Oklahoma	3,085	210,713	7,725,925,945
Oregon	1,459	56,360	2,777,077,198
Pennsylvania	1,021	210,987	7,397,603,384
Rhode Island	73	26,602	1,145,969,064
South Carolina	3,935	155,543	5,237,343,635
South Dakota	2,057	53,596	1,858,269,278
Tennessee	2,336	167,644	5,640,679,477
Texas	16,837	1,069,378	36,331,534,634
Utah	809	28,027	1,509,421,589
Vermont	226	13,588	490,304,437
Virginia	1,979	147,015	6,707,630,446
Washington	1,668	93,653	3,624,944,099
West Virginia	420	31,136	1,089,375,126
Wisconsin	3,001	139,467	5,992,923,093
Wyoming	1,064	8,773	421,021,028
TOTAL	146,601	9,576,877	390,052,507,764

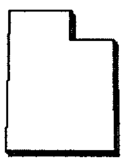
Note: Floodplain area comprises the one percent annual chance ("100-year") floodplain.

Source: Donnelley Marketing Information Service. System Update Report. 1987. (Refinement of 1987 study based on remeasurement of Special Flood Hazard Areas in the top 2,000 communities having property at risk and a statistical adjustment to the other floodprone properties.) FEMA, 1991.

FLOODPLAIN DEVELOPMENT AND AWARENESS OF THE FLOOD HAZARD

Development of floodplains in any part of the country usually results in damages. Urbanization can cause dramatic increases in runoff, both from reduction of impervious area in a watershed and from decreased travel times for the accumulation of flood peaks. Land uses other than urbanization can also lead to increased flood damages, particularly if the uses cause changes in the sediment load or changes in the channels themselves. Upstream development, outside the floodplain can also increase flood peaks.

Extreme events such as storms and floods are basically random occurrences, even though their long-term average recurrence interval can be predicted. Random occurrence can sometimes result in several years of severe flooding followed by a period with little or no flooding. Too often, it is during these times of little or no flooding that much development at risk to floods occurs. Residents, developers and officials may forget or even be unaware of past floods. An example of this type of inappropriate development is provided by Davis County, Utah.



Davis County, which lies between the Great Salt Lake and the Wasatch Mountains north of Salt Lake City, Utah, has experienced rapid growth during the past 20 or 30 years. Throughout the county, substantial encroachment on stream banks and foothill development has occurred. Over much of this period of growth, the climate was relatively dry, allowing officials to forget the tremendous precipitation events and accompanying flood devastation of earlier times. The early 1980s, however, were a series of wet years.

"In 1983, a cool spring kept a greater than average snow pack from melting until 90 degree + temperatures brought the runoff down all at once. The peaceful little brooks turned into raging torrents, washing everyone's yard accessories into the fences built across the channels, and forcing flood waters into nearby homes and streets. Millions of dollars worth of damage was done in a short time by these innocent looking little brooks. Residents were angry and wanted to know why they weren't protected or at least warned. Weather patterns persisted, but by the next year some major channel improvements and flood control structures had been completed and residents were prepared with sand bags and changed perceptions of their friendly little backyard stream. Major channel systems and debris basins have alleviated the widespread flooding, but residents still put themselves and their neighbors in jeopardy by insisting on stream encroachment as part of their landscaping scheme."

Despite these improvements, the county again suffered extensive damage in the summer of 1986, when an intense thunderstorm caused almost every type of urban flooding. "Extensive investigation found that much of the damage could have been averted through better awareness of residents and officials as to the flood dangers of hillside development, improper lot grading, and changes in natural drainage paths. Many residents were surprised and angered to find themselves in unperceived jeopardy after living in their homes, trouble free, for several years" (Williams, 1987).

DEVELOPMENT IN COASTAL REGIONS

The coastlines of the United States have been attracting people in ever increasing numbers for several decades. The value of property at risk to coastal storms has also increased tremendously in recent decades. Initially, much of the development along the Atlantic and Gulf coasts and parts of the Pacific coast was primarily for second homes and seasonal tourism. While these uses still predominate in many areas, seasonal cottages have increasingly been converted to year-round use and the traditional summer tourist season has gradually expanded to encompass the entire year in many locations. Two examples help to illustrate the phenomenon of coastal growth.

In Rhode Island the number of houses in the salt pond region on the state's south coast tripled from 1950 to 1980. During this same period, but particularly in recent years, hundreds of summer cottages have been converted to year round use. The increase in population and development has caused major concerns about the potential for losses during a major hurricane and degradation of the coastal environment, including ground water supplies due to inadequate sewage disposal (Olsen, 1985).

Ocean City, Maryland — located entirely on a coastal barrier — has shown dramatic growth since the last major flooding in 1962. By 1983 Ocean City had a permanent population of under 6,000, but on peak summer weekends, the population was estimated to exceed 250,000. The City has been extensively developed with individual homes, businesses, motels, mobile homes and high-rise motel and condominiums in order to accommodate this large number of visitors (IEP, 1984).

Population in Coastal Areas

The 1980 United States census identified 611 counties and independent cities that are "entirely or substantially within 50 miles of U.S. coastal shorelines." Census units within 50 miles of the Atlantic and Gulf coastlines increased in population from 34.1 million in 1940 to 63.3 million in 1980 — an increase of 85% as compared with 70% for the Nation as a whole. Gulf Coast counties increased by 200% (West, 1987). Tables 3-2 and 3-3 show regional population changes in coastal areas from 1960 to 1980. It has been estimated that by the year 1990, 75 percent of the United States population will live within 50 miles of tidal waters and the Great Lakes (Olsen, 1985).

Development of adequate evacuation routes has not kept pace with development of coastal barriers and other high risk coastal areas. Nearly 80% of the people now living in barrier communities have never experienced a hurricane. Even if the population at risk responds to an evacuation order, not all would be able to evacuate in time (Monday, 1983).

Coastal Barriers

Coastal barriers serve as important buffers against mainland flooding and erosion. Without the protection of coastal barriers, large population centers on the mainland coasts would be exposed to direct attack by hurricanes and other coastal storms. The barriers themselves are also extremely vulnerable to flooding and erosion due to their seaward exposure and the inherent instability and relatively low-lying topography of these landforms. Over 90% of the barriers along the United States coastline have been judged to be subject to flooding from severe storms.

Table 3-2. Regional Population Densities in Coastal Counties With Coastal Barriers, 1960-1980. (population per square mile)

REGION (No. of Counties)	1960	1970	PERCENT CHANGE 1960-70	1980	PERCENT CHANGE 1970-80
New England (11)	490	540	10.2	571	5.7
North Central Atlantic (9)	736	940	27.7	1223	31.2
South Central Atlantic (11)	108	144	33.3	178	23.6
South Atlantic (11)	175	263	50.3	381	44.9
Gulf (16)	146	190	23.3	255	34.2

Source: West, Niels. "Population Changes in Coastal Jurisdictions with Barrier Beaches: 1960-1980." In Cities on the Beach: Management Issues of Developed Coastal Barriers. University of Chicago Research Paper No. 224. University of Chicago, 1987.

Table 3-3. Regional Population Changes in 156 Local Jurisdictions Containing Coastal Barriers, 1960-1980.

REGION	1960	1970	PERCENT CHANGE 1960-70	1980	PERCENT CHANGE 1970-80
New England	251,915	362,133	43.7	464,823	28.0
North Central Atlantic	1,993,414	2,243,803	12.6	2,218,247	-1.1
South Central Atlantic	35,506	206,320	484.3	330,761	60.3
South Atlantic	359,872	653,294	81.5	831,587	27.1
Gulf	1,043,177	1,292,571	23.9	1,631,137	26.2

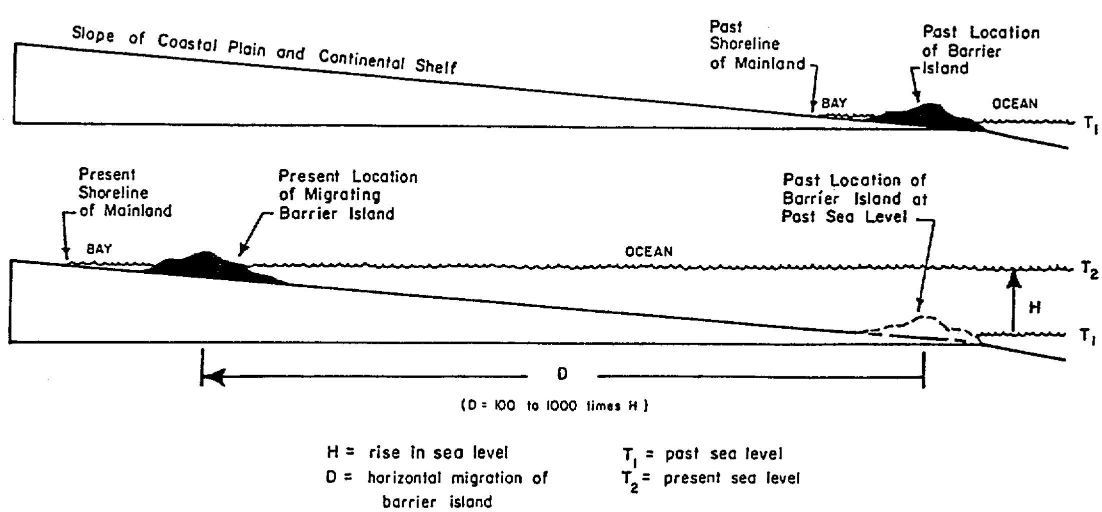
Source: West, Niels. "Population Changes in Coastal Jurisdictions with Barrier Beaches: 1960-1980." In Cities on the Beach: Management Issues of Developed Coastal Barriers. University of Chicago Research Paper No. 224. University of Chicago, 1987.

The natural erosion and migration rates of most coastal barriers are high. Lands now being considered for building sites may be highly eroded or have simply disappeared within several years as storm waves breach and overwash barriers, inundating or eroding entire sections. Rising sea level is also a factor in the long-term instability of coastal barriers. Without human interference, coastal barriers can respond to slowly rising sea levels by continuously moving landward (migrating) or by being submerged (drowning) as shown on Figure 3-1 (Leatherman, 1982).

In spite of the risks and the difficulties associated with maintaining stable development in an environment subject to constant change, increased residential and other types of development have occurred on coastal barriers in recent decades, and pressures for continued development are intense. Many of the major resorts on the Atlantic coast — including Atlantic City, Ocean City, Virginia Beach and Miami — are located on coastal barriers. Current development pressures on coastal barriers are consistent with the overall intense pressures for growth and development throughout the entire coastal area of the United States. Populations in the coastal states are growing at a rate of three to four times the national average, and coastal barriers are urbanizing at a rate twice that of the nation as a whole. While only 3% of the mainland is now considered "urban land," 14% of the area of coastal barriers is urbanized (Conservation Foundation, 1982).

Increased development on coastal barriers has resulted in large numbers of people and personal property being at risk to severe storms. This added development also interferes with the natural ability of the barriers to absorb storm energies, thereby reducing protection for mainland populations and development.

With sea level rise a barrier must retreat up the gradually sloping coastal plain over geologic time. Without migration, the barrier can be drowned.



Source: Leatherman, Stephen. Barrier Island Handbook. College Park, Maryland: University of Maryland, 1980.

Figure 3-1. Migration of a Barrier Island in Response to Sea Level Rise.

Along with increased development of coastal barriers have come increased efforts to establish structural works and other measures intended to protect this development and the investments involved. Traditional protection and stabilization measures such as groins, jetties, bulkheads and seawalls, however, interfere with the natural sand transport processes that contribute to the dynamic equilibrium of coastal barriers. In the longer term, these structural measures, together with other development impacts, such as alteration of primary dunes, maintenance of navigation channels and ground water extraction and contamination, may seriously degrade or destroy the natural values of coastal barriers and may even destroy the barrier itself.

DEVELOPMENT IN ARID REGIONS

The arid and semi-arid southwest is another geographic region that has undergone rapid growth in recent years, and that growth is projected to continue well into the next century (see Chapter 15). Sparse but intense rainfall, combined with the presence of unstable channels and alluvial fans, create particularly severe flood problems when these arid regions undergo rapid development. Man's activities have already profoundly affected floodplains and the nature of flooding throughout the southwest. Many changes that began 450 years ago with the introduction of cattle are still affecting the basic hydrologic cycle and geomorphology. Plant and animal associations that evolved over a 10,000 year period have been irreversibly altered, and the effects are still only vaguely understood and generally unmanaged (Dobyns, 1981).

IMPACTS OF DEVELOPMENT ON FLOODPLAIN NATURAL RESOURCES

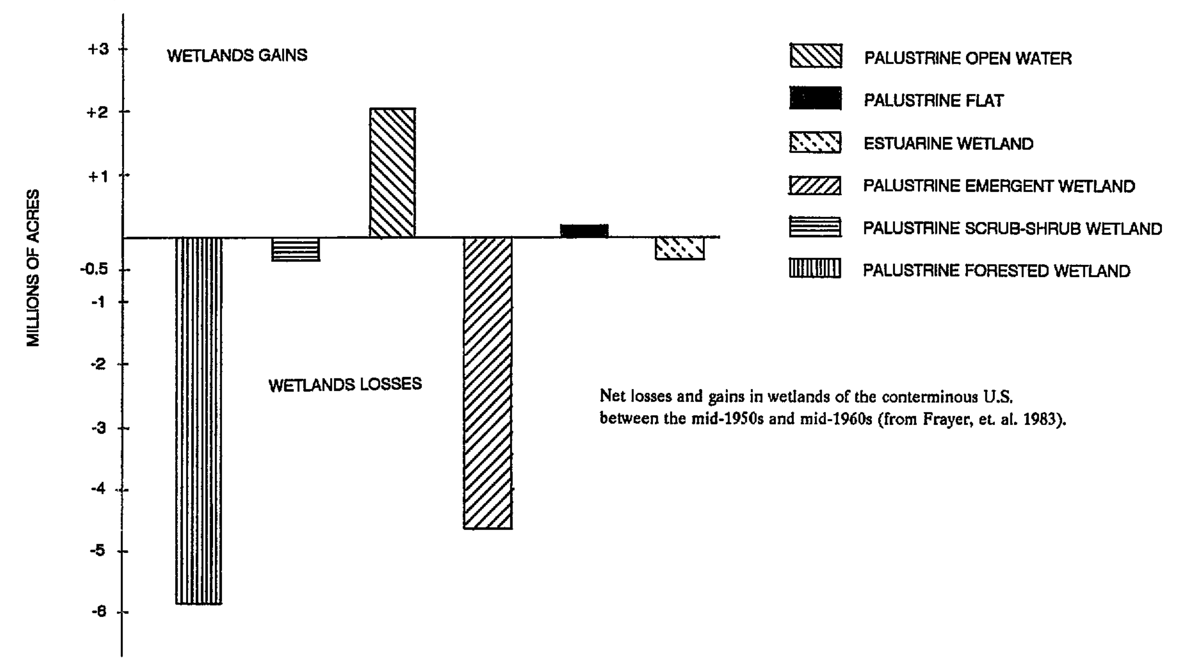
Of particular concern with regard to the impacts of development on the natural resources of floodplains are actual and potential impacts on floodplain wetlands and riparian habitat.

IMPACTS ON WETLANDS

Not until the environmental movement of the late 1960s and 1970s did the natural resources of floodplains become widely recognized and appreciated. Prior to that time (and continuing to a great extent today) swamps and other wetlands were viewed primarily as areas to be filled or drained and converted to "productive" uses. Although information on original wetland acreage in the United States is incomplete, it is estimated that approximately 54% of the 215 million wetland acres estimated in existence at the time of European settlement of the country has since been lost (Tiner, 1984).

Wetland loss in the last 30 years has been particularly dramatic, despite gains in certain types of wetlands (inland flats and ponds). Figure 3-2 shows estimates of net losses and gains in wetlands.

> *In the mid-1950s, there were an estimated 108.1 million acres of wetlands in the lower 48 states (Frayer, et al. 1983). Just 20 years later, these wetlands were reduced to 99 million acres, despite some gains in wetlands due to reservoir and pond construction, beaver activity, and irrigation and marsh creation projects. Although 11 million acres of wetlands were lost, this was offset by gains of 2 million acres of new wetlands, yielding a net loss of 9 million acres. This loss of 9 million acres equates to an area about three times the size of Connecticut or twice the size of New Jersey (Tiner, 1984).*



Source: Tiner, Jr., Ralph W. Wetlands of the United States: Current Status and Recent Trends. Newton Corner, Massachusetts: U.S. Fish and Wildlife Service, Habitat Resources, 1984.

Figure 3-2. Net Losses and Gains in Wetlands of the Conterminous U.S., Mid-1950s to Mid-1970s.

Annual losses of wetlands have been estimated at close to one-half million acres. "The average rate of wetland loss from the mid-50s to mid-70s was 458,000 acres per year: 440,000 acres of palustrine losses and 18,000 acres of estuarine wetland losses.[2] This annual loss equals an area about half the size of Rhode Island" (Tiner, 1984). It has been estimated that if losses continued at those current rates, less than 40 percent of the original wetlands of the United States would remain by the year 2000 (Conservation Foundation, 1982). Current estimates of wetland loss vary from 300,000 to 450,000 acres annually (Melanson, 1989). In recent years, however, the advent of laws and regulatory programs to protect wetlands (such as the Section 404 Program under the Clean Water Act) and the termination of programs that provided technical and financial support for wetland drainage, have helped to reduce wetland losses.

Historically, the greatest portion of wetland loss has resulted from draining wetlands for conversion to agricultural purposes. Other major losses have resulted from filling and/or draining for residential/commercial development, drainage for mosquito control, drainage and digging of canals for oil development, lowering of water tables, and erosion. Table 3-4 lists the major causes of wetland loss and degradation, and Figure 3-3 depicts the major causes of recent wetland losses. In some areas of the country, notably in Louisiana, in the bottomland hardwood regions of the Mississippi Valley, in coastal areas of the Atlantic coast, and in the prairie pothole region, losses have been very significant (Tiner, 1984). Table 3-5 shows some regional examples of wetland losses, and Table 3-6 provides examples of recent rates of wetland losses.

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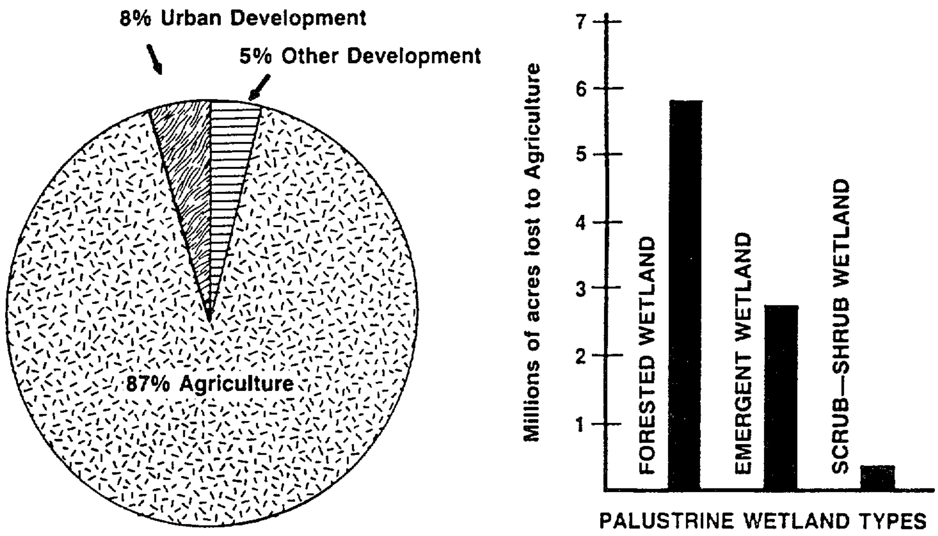
2 See Chapter 2 for a description of palustrine, estuarine and other categories of wetlands.

Table 3-4. Major Causes of Wetland Loss and Degradation.

I. HUMAN THREATS
   A. Direct
      1. Drainage for crop production, timber production and mosquito control.
      2. Dredging and stream channelization for navigation channels, flood protection, coastal housing developments, and reservoir maintenance.
      3. Filling for dredged spoil and other solid waste disposal, roads and highways, and commercial, residential and industrial development.
      4. Construction of dikes, dams, levees, and seawalls for flood control, water supply, irrigation and storm protection.
      5. Discharges of materials (e.g., pesticides, herbicides, other pollutants, nutrient loading from domestic sewage and agricultural runoff, and sediments from dredging and filling, agricultural and other land development) into waters and wetlands.
      6. Mining of wetland soils for peat, coal, sand, gravel, phosphate, and other materials.
   B. Indirect
      1. Sediment diversion by dams, deep channels and other structures.
      2. Hydrologic alterations by canals, spoil banks, roads, and other structures.
      3. Subsidence due to extraction of groundwater, oil, gas, sulphur, and other minerals.

II. NATURAL THREATS
      1. Subsidence (including natural rise of sea level)
      2. Droughts
      3. Hurricanes and other storms
      4. Erosion
      5. Biotic effects, e.g., muskrat, nutria and goose "eat-outs."

Source: Tiner, Jr., Ralph W. Wetlands of the United States: Current Status and Recent Trends. Newton Corner, Massachusetts: U.S. Fish and Wildlife Service, Habitat Resources, 1984.



Source: Tiner, Jr., Ralph W. Wetlands of the United States: Current Status and Recent Trends. Newton Corner, Massachusetts: U.S. Fish and Wildlife Service, Habitat Resources, 1984.

Figure 3-3. Causes of Recent Wetland Losses.

Table 3-5. Wetland Losses in Various States.

STATE OR REGION	ORIGINAL WETLANDS (ACRES)	TODAY'S WETLANDS (ACRES)	% OF WETLANDS LOST	SOURCE
Iowa's Natural Marshes	2,333,000	26,470	99	Bishop (1981, pers. comm.)
California	5,000,000	450,000	91	U.S. Fish and Wildlife Service (1977)
Nebraska's Rainwater Basin	94,000	8,460	91	Farrar (1982)
Mississippi Alluvial Plain	24,000,000	5,200,000	78	MacDonald, et al.(1979)
Michigan	11,200,00	3,200,000	71	Michigan DNR (1982)
North Dakota	5,000,000	2,000,000	60	Elliott, U.S. FWS (pers. comm.)
Minnesota	18,400,000	8,700,000	53	University of MN (1981)
Louisiana's Forested Wetlands	11,300,000	5,635,000	50	Turner and Craig (1980)
Connecticut's Coastal Marshes	30,000	15,000	50	Niering (1982)
North Carolina's Pocosins	2,500,000	1,503,000*	40	Richardson, et. al. (1981)
South Dakota	2,000,000	1,300,000	35	Elliott, U.S. FWS, (per. comm.)
Wisconsin	10,000,000	6,750,000	32	Wisconsin DNR (1976)

* Only 695,000 acres of pocosins remain undisturbed; the rest are partially drained, developed or planned for development.

Source: Tiner, Jr., Ralph W. Wetlands of the United States: Current Status and Recent Trends. Newton Corner, Massachusetts: U.S. Fish and Wildlife Service, Habitat Resources, 1984.

Table 3-6. Examples of Wetland Loss Rates.

STATE OR REGION	LOSS RATE (acres/year)	RATE SOURCE
Lower Mississippi Alluvial Plain	165,000	MacDonald, et al. (1979)
Louisiana's Forested Wetlands	87,200	Turner and Craig (1980)
North Carolina's Pocosins	43,500	Richardson, et al. (1981)
Prairie Pothole Region	33,000	Haddock and DeBates (1969)
Louisiana's Coastal Marshes	25,000	Fruge (1982)
Great Lakes Basin	20,000	Great Lakes River Basin Comm. (1981)
Wisconsin	20,000	Wisconsin DNR (1976)
Michigan	6,500	Weller (1981)
Kentucky	3,600	Kentucky Fish & Wildlife Resources (1983)
New Jersey's Coastal Marshes	3,084	Ferrigno, et al. (1973)
	*50	JACA Corporation (1982)
Palm Beach County, Florida	3,055	U.S. FWS (1982)
Maryland's Coastal Wetlands	1,000	Redelfs (1983)
	*20	
New York's Estuarine Marshes	740	O'Conner and Terry (1972)
Delaware's Coastal Marshes	*20	Hardisky and Klemas (1983)

* Loss rate after passage of state coastal wetland protection law.

Source: Tiner, Jr., Ralph W. Wetlands of the United States: Current Status and Recent Trends. Newton Corner, Massachusetts: U.S. Fish and Wildlife Service, Habitat Resources, 1984.

Wetland losses due to agricultural drainage appear to be substantially less today than in the earlier part of this century. Studies by the Soil Conservation Service (SCS) indicate that there was a large amount of drainage activity between 1900 and 1920, a relatively flat period in terms of activity between 1920 and 1945, and then an increasing trend (although at a decreasing rate) from 1945 to 1980 (Heimlich, 1986). During the last half of the 1980s wetland drainage for agricultural purposes is believed to have decreased significantly due to several factors. A major factor is the Swampbuster section of the Food Security Act of 1985. Under this section, farmers who would drain additional wetlands to produce commodities would stand to lose agricultural price subsidies on their entire farm operation. Other factors contributing to the decrease of wetland drainage for agricultural purposes include a reduction in the export of food commodities from the peak of former years, and a lowering of the commodity prices received by farmers from the prices received during the 1970s and early 1980s (von Wolffraαt, 1988; Soil Conservation Service, 1989).

IMPACTS ON RIPARIAN HABITAT

Riparian ecosystems are also being degraded and destroyed throughout the United States. The lower 48 states originally contained between 75 and 100 million acres of indigenous, woody riparian habitat. Today, only 35 million acres remain in near natural condition. The rest have been inundated, channelized, dammed, rip-rapped, converted to agricultural use, overgrazed, or altered by a combination of factors that impede their ability to stabilize and maintain the biological diversity of their watersheds (Hunt, 1985).

Channelization and other flood control projects can greatly reduce flood losses, but these measures can also destroy riparian habitat by clearing vegetation, preventing bank overflow with levees, eliminating sandbar habitat, islands and productive backwater areas, and accelerating bank erosion. As a result of these types of projects by federal, state and local governments, a large amount of riparian habitat has been lost in years past. For example, between 1940 and 1971 the Corps assisted in navigation improvement and flood control projects that altered 11,000 miles of streams. The SCS has installed 10,700 miles of channel modifications and an additional 10,500 miles of modifications have been authorized (von Wolffradt, 1988). Due to environmental considerations, only a fraction of the authorized channel work will be built (U.S. Department of Agriculture, 1989).

Dam construction can alter riparian habitat in many ways. The habitat can be drowned by reservoirs, desiccated by downstream de-watering, or rendered nonregenerative by natural flood cycle interruptions. A 1982 Corps of Engineers survey (U.S. Army Corps of Engineers, 1982) found that the Nation's rivers support 68,153 nonfederal dams. These privately owned dams have altered or destroyed tens or hundreds of thousands of miles of riparian habitat. Construction of impoundments by the federal government has transformed major river systems — such as the Columbia, Colorado and Missouri — into a series of artificial lakes and severely decreased the diversity of habitats available to wildlife. More recently, Congress has authorized 934 additional major federal water projects and needs only to appropriate funds before actual construction can begin. Proposed riverine alterations greatly outnumber the stream segments currently protected under federal or state statutes.

Today, however, channelization and other flood control projects are generally carried out with much greater sensitivity to natural resources. For example, all channel work installed by the SCS must have an environmental impact statement and be consistent with the Stream Channel Guidelines mutually agreed upon by the SCS and the Fish and Wildlife Service (FWS). Channel location is selected to avoid wetlands or channels are constructed to have minimal adverse impacts on both wetlands and riparian habitat. Improved construction techniques include such practices as construction from one side only, use of winding channel work to follow natural channel locations, avoiding clearing of mature trees that are significant sources of cover and food for wildlife, and widespread use of wildlife-supporting natural wildlife plantings to ensure that channel work will fit into natural stream systems and be shaded (von Wolffradt, 1988).

Overgrazing has done great damage to watersheds and riparian zones, and inadequate livestock management has been responsible for the lack of riparian habitat regeneration on federal range lands in the west. The negative impacts of overgrazing include soil compaction, denudation of watershed areas, removal of riparian vegetation, and the mechanical breakdown of streambanks as caused by livestock. These impacts generally lead to increased soil erosion (and increased sediment loads and turbidity in streams), increased nutrient load in streams, bank erosion and lowering of water tables. Management practices suggested to alleviate these problems center on timing the grazing to avoid times of the year when the most damage is done (Bryandt, 1985).

Lowering of the water table in arid and semi-arid regions causes a drastic and often permanent degradation of natural floodplain resources. In many areas, a high water table is the only source of water for riparian vegetation. Permanent pools and springs may be the only local sources of water for native animals. The pumping of ground water, construction of agricultural drains, and channelization, both intentional and incidental to these activities, may lower the water table and change entire ecosystems.

Introduction of nonnative plant species can also contribute to degradation of riparian habitat and wetlands. Invasion of riparian areas by salt cedar, imported to North America during the 19th century, for example, has reduced the value of riparian areas for many native bird species. Salt cedar has become the predominant riparian tree species in the Lower Colorado, the Lower Rio Grande and the Pecos Rivers, covering some 500 square miles in those basins alone (Hunter, 1985). Purple loosestrife is another nonnative species that can dominate wetlands. This species is particularly harmful to wetlands because it spreads rapidly and has low food value for wildlife. It is spreading from the northeast westward. Many other invader species also pose problems (Meagher, 1988). On the other hand, some nonnative species can have beneficial impacts. A 45,000 acre irrigated pecan grove on the Santa Cruz River in southern Arizona, for example, has created a pseudo-riparian environment that is used by many native species of birds, mammals and other animals (Kingsley, 1985).

Riparian habitat has been lost in every region of the country. Southwestern riparian woodlands have declined drastically since the late 19th century, and losses have been extensive in the midwest. Northeastern states originally lost riparian habitat to agriculture, livestock grazing, and urbanization. Much riparian habitat in the northeast has returned due to abandonment of farmland and subsequent reforestation, but increasing demands for housing, recreation and hydropower constitute continuing threats to riparian habitat. Southeastern riparian communities are gradually losing ground to intensive forest practices, housing developments and agricultural conversions. In the Northwest, hydropower development and associated activities — such as road construction or relocation, wetlands drainage, stream channelization, and shoreline riprapping — have also adversely impacted the region's riparian communities (Hunt, 1985).

In 1848, California's Sacramento River supported about 775,000 acres of oak, sycamore, ash, willow, walnut, alder, poplar, and wild grape on its banks. At the turn of the century, vast tracts had been cleared for agricultural development and by 1977 the Sacramento's banks had a mere 12,000 acres of native riparian vegetation. On the Colorado River's lower reaches in California and Arizona, vast tracts of riparian woodlands were cut in the late 1800s to fuel steamboats (Johnson, 1978).

Loss of riparian ecosystems has been documented throughout the Nation:

- A 1981 study by the New England River Basins Commission (NERBC) estimated that only 5% of the region's total river mileage remains free-flowing, with 30-40 new hydropower dams proposed for those reaches (New England River Basins Commission, 1981).
- The Missouri River was extensively developed in response to the dust bowl in the mid-1930s and a series of floods in the 1940s. River channelization to stabilize the river, increase its navi-

gability, and produce hydropower has eliminated all the oxbow lakes that were valuable for overflow storage and ground-water recharge, as well as backwater and sand bar wildlife habitat. The result has been a loss of 309,000 acres of terrestrial habitat and 100,300 acres of aquatic habitat. In 1980, approximately 640 acres of riparian habitat existed for each mile of river, but by 1985, the ratio had dropped to 140 acres per mile, with most of the remaining acreage converted to farmland (Hunt, 1985).

- The taming of the Columbia River began in the period just after the Civil War with nonfederal dredging operations. The Corps of Engineers completed Cascades Lock in 1896. Activities continued in 1933 with Congressional approval of the Bonneville and Grand Coulee Dams, and by 1973, 28 dams had been built on the Columbia and its tributaries. The reservoirs behind the dams inundated many additional miles of riparian habitat and water release fluctuations created barren zones on the river's banks (Bureau of Reclamation, 1991).

HISTORICAL LOSSES FROM FLOODS

Flooding and flood related events such as hurricanes annually cause greater damages and result in more Presidentially declared disasters than all other forms of natural hazards combined. From 1965 through 1989, there were 657 Presidential disaster declarations, of which 508 (77 percent) were flood related (Federal Emergency Management Agency, 1985, 1989).

Any discussion of flood losses is hindered by the lack of uniform and systematic application of definitions of "flood" and "flood loss" applied to the collection of data from natural disasters. For example, deaths due to a helicopter crash during an evacuation operation may or may not be attributed as "flood-related." There may be thousands of incidents each year where a few houses are damaged by local flooding or storm drainage problems, but there is no uniform accounting for these damages. Even the accounting for Presidential disaster declarations does not usually differentiate between flood-caused damages and damages caused by wind, for example.

ESTIMATES OF PROPERTY DAMAGES AND DEATHS FROM FLOODING

Although reasonably good information is available for the great floods that have caused serious loss of life or major damages to property, equivalent information is frequently not available for the multitude of smaller flood events, and there is no complete record of past flood damages in the United States. Due to differences in reporting flood losses (e.g., with reference to floods vs. storms, with regard to major flood disasters vs. smaller flood events) and in adjusting dollar amounts to reflect changes in monetary values, as well as other problems in coordinating data sources (e.g., federal vs. nonfederal outlays), interpretation of flood loss data is difficult and estimates are not necessarily comparable (Rubin, 1986). The two most comprehensive sources of annual flood loss data are those prepared by the National Weather Service (NWS) and the American National Red Cross.

Since 1902, the NWS has annually compiled estimates of damages caused by floods (excluding losses to agriculture) and of the number of lives lost due to floods. Estimates are initially prepared by local NWS offices using information obtained from a variety of sources, including government officials and news media.[3] Data from local offices is compiled by NWS offices in Silver Spring, Maryland and may be supplemented by additional information, such as that supplied by other federal agencies. Until 1975, damage estimates were prepared for each state and national totals were also compiled. Beginning in 1976, only the national totals were released by the NWS (Stallings, 1988).

In order to provide the data to Congress by January of each year, the NWS damage estimates are produced immediately after the close of the federal fiscal year at the end of September and are never revised to reflect later damage figures that may be more accurate and/or complete. In the worst case, damage estimates for a flood that occurs in August or September are very rough and probably still incomplete by the October 1 deadline. Even though better figures may become available months later, they are never reflected in the NWS reports or in any other published form. Despite many deficiencies and other known problems with regard to the NWS data on flood-related deaths and damages, these data provide the most complete and consistent information over the longest period of record. Detailed analysis of these data could be misleading, but gross trends should be reasonably evident.

Table 3-7 provides NWS estimates of loss of lives and loss of life per 200 million population in the U.S. from 1916 to 1989. (The U.S. Census estimate of the Nation's 1985 population was 238.7 million. It should be pointed out that there are inconsistencies between the annual deaths reported in Table 3-7 and the deaths that have been attributed by other sources to specific flood events as reported in Appendix A of the *Assessment Report.*) Table 3-8 provides NWS estimates for property damages for the same period, both in current dollars and dollars adjusted to 1985 values.[4] The flood damage data in Table 3-8 are also shown per 200 million population. Data for flood-related deaths and damages are displayed graphically on Figures 3-4 and 3-5.

Examination of the data in Table 3-7 and Figure 3-4 does not indicate a trend in the annual number of flood-related deaths once the number is adjusted in accordance with population changes. The adjusted average annual deaths (per 200 million population) for the entire 74-year period shown in Table 3-7 is 124.7. In the 25-year period from 1916 through 1940, there was an adjusted average of 153.7 deaths per year; in the period 1941 through 1965 the average was 86.1; and in the period 1966 through 1985 the average was 144.8. Given the impact of one or two catastrophic events such as a dam failure or a major hurricane on flood-related deaths, there is no indication that flood-related deaths are increasing or decreasing on a per capita basis.

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3 Although a standardized form is used, no firm procedure or stringent requirements for completeness has been established by the NWS. Hence, data submitted by local offices may vary widely in quality.

4 In an effort to provide consistent figures, all dollar figures in this chapter have been converted to 1985 values wherever possible. The Consumer Price Index was used for this conversion. In many sources, the basis of the dollar values was not given, and no effort was made to convert these figures. Readers are advised to obtain data from the original sources for purposes of additional analysis.

Table 3-7. National Weather Service Estimates of Flood-Related Deaths in the United States, 1916-1989.

FLOOD-RELATED DEATHS IN THE UNITED STATES

YEAR	DEATHS	DEATHS PER 200 MIL. POP
1916	118	235
1917	80	159
1918	0	0
1919	2	4
1920	42	79
1921	143	269
1922	215	404
1923	42	79
1924	27	51
1925	36	62
1926	16	28
1927	423	731
1928	15	26
1929	89	154
1930	14	23
1931	0	0
1932	11	18
1933	33	54
1934	88	143
1935	236	371
1936	142	223
1937	142	223
1938	180	283
1939	83	130
1940	60	91
1941	47	70
1942	68	101
1943	107	158
1944	33	49
1945	91	136
1946	28	40
1947	55	76
1948	82	112
1949	48	64
1950	93	122
1951	51	66
1952	54	65
1953	40	50
1954	55	67
1955	302	366
1956	42	50
1957	82	96
1958	47	54
1959	25	28
1960	32	36
1961	52	59
1962	19	20
1963	39	41
1964	100	105
1965	119	122
1966	31	32
1967	34	34
1968	31	31
1969	297	295
1970	135	132
1971	74	72
1972	554	529
1973	148	140
1974	121	113
1975	107	99
1976	193	177
1977	210	191
1978	143	129
1979	121	108
1980	82	72
1981	84	73
1982	155	133
1983	204	174
1984	126	107
1985	304	255
1986	206	172
1987	130	109
1988	37	31
1989	32	27

NOTE: Annual population figures not available for 1915-1939. Population figure used to calculate "Deaths/200 Mil. Pop.." was the figure for the end of a five-year period. For example, the 1920 population figure was used for the years 1916-1920. The 1985 population figure was used for the years 1986 to 1989. "Resident Population" was used for all years.

Sources: Deaths — Schilling, Kyle, and others. The Nation's Public Works: Report on Water Resources. National Council on Public Works Improvement, Categories of Public Works Series, 1987. (Based on NWS data; updated to 1989.)

Population — Bureau of the Census. Statistical Abstract of the United States 1989. Washington, D.C.: U.S. Department of Commerce, 1989.

Table 3-8. National Weather Service Estimates of Flood-Related Damages in the United States, 1916-1989.

FLOOD-RELATED DAMAGES IN THE UNITED STATES
(in millions of dollars)

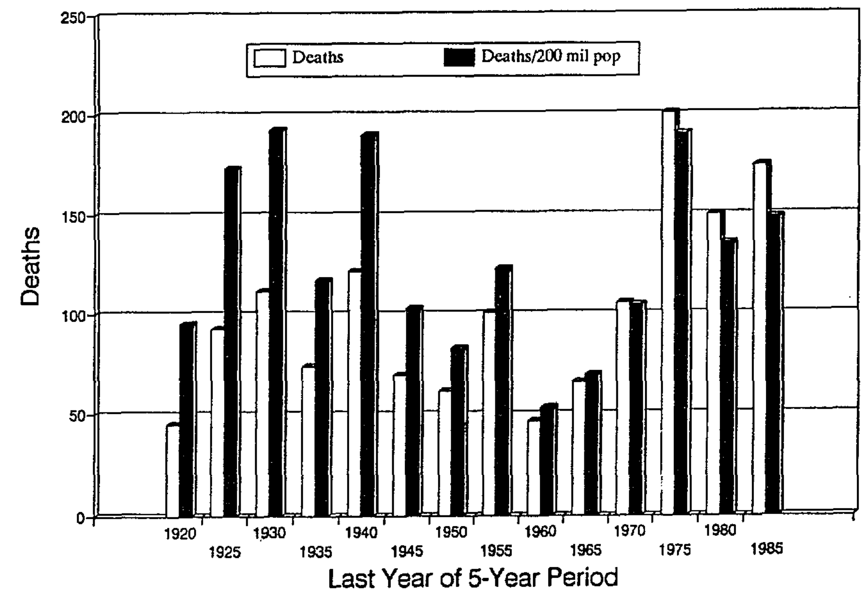
YEAR	DAMAGES	DAMAGES (1985 $)	DAMAGES PER 200 MIL. POP. (1985 $)	YEAR	DAMAGES	DAMAGES (1985 $)	DAMAGES PER 200 MIL. POP. (1985 $)
1916	26	256	481	1953	122	491	618
1917	27	227	427	1954	107	428	529
1918	8	57	107	1955	995	3,997	4,842
1919	3	19	36				
1920	25	134	252	1956	65	257	306
				1957	360	1,376	1,607
1921	29	174	301	1958	218	811	931
1922	52	334	577	1959	141	520	587
1923	53	334	577	1960	93	338	376
1924	17	107	185				
1925	10	61	105	1961	154	554	605
				1962	75	267	287
1926	23	140	228	1963	118	414	439
1927	348	2,156	3,506	1964	652	2,261	2,366
1928	45	283	460	1965	788	2,687	2,777
1929	68	427	694				
1930	16	103	167	1966	117	388	397
				1967	375	1,209	1,224
1931	3	21	33	1968	339	1,049	1,052
1932	10	79	124	1969	901	2,645	2,627
1933	37	307	482	1970	157	435	426
1934	10	80	126				
1935	127	996	1,565	1971	287	762	737
				1972	4,465	11,484	10,974
1936	283	2,197	3,316	1973	1,894	4,586	4,339
1937	441	3,304	4,987	1974	566	1,235	1,158
1938	101	771	1,164	1975	1,248	2,495	2,316
1939	14	108	163				
1940	40	307	463	1976	1,240	2,344	2,154
				1977	1,482	2,631	2,394
1941	40	292	437	1978	3,150	5,195	4,678
1942	99	654	972	1979	5,279	7,825	6,968
1943	200	1,244	1,842	1980	1,774	2,316	2,038
1944	101	617	922				
1945	166	992	1,487	1981	906	1,072	934
				1982	1,377	1,535	1,323
1946	71	391	556	1983	2,388	2,580	2,202
1947	272	1,310	1,818	1984	1,543	1,598	1,351
1948	230	1,028	1,401	1985	3,536	3,536	2,963
1949	94	424	568				
1950	176	787	1,036	1986	6,007		
				1987	2,084		
1951	1,029	4,261	5,534	1988	500		
1952	254	5,534	1,316	1989	1,100		

NOTE: Annual population figures not available for 1915-1939. Population figure used to calculate "Deaths/200 Mil. Pop." was the figure for the end of a five-year period. For example, the 1920 population figure was used for the years 1916-1920. The 1985 population figure was used for the years 1986 to 1989. "Resident Population" was used for all years.

Sources: Damages — National Weather Service, Silver Spring, Maryland, updated to 1989.

Population — Bureau of the Census. Statistical Abstract of the United States 1989. Washington, D.C.: U.S. Department of Commerce, 1989.

CPI — Bureau of the Census. Historical Statistics of the United States: Colonial Times to 1970, Part 1 (1916-1966). Washington, D.C.: U.S. Department of Commerce, 1976; Council of Economic Advisors, various dates; U.S. General Services Administration. Economic Indicators. Washington, D.C.: Superintendent of Documents, U.S. Government Printing Office, (1967-1988).

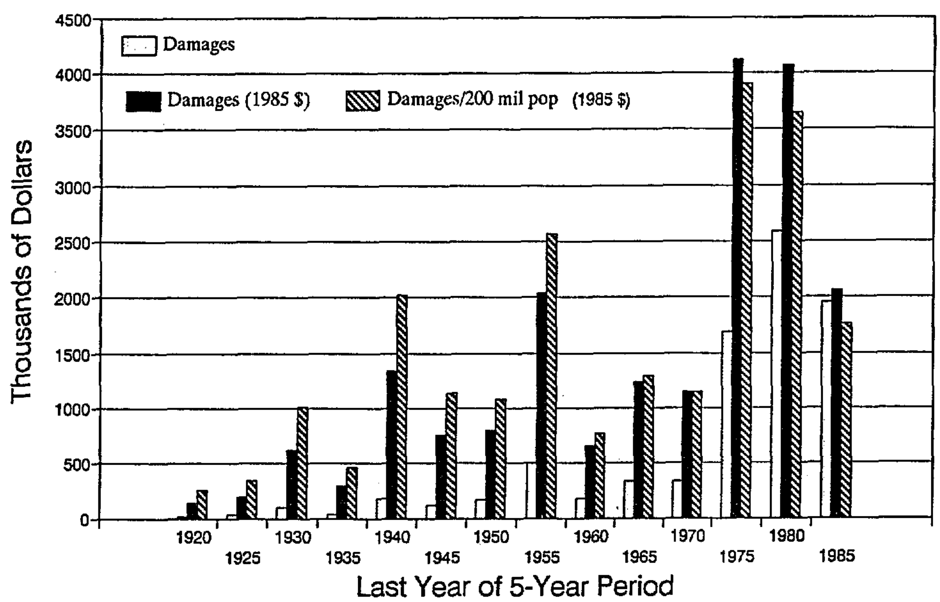


NOTE: Date shown is the last year of the five-year period.

Sources: Deaths — Schilling, Kyle, and others. The Nation's Public Works: Report on Water Resources. National Council on Public Works Improvement, Categories of Public Works Series, 1987. (Based on NWS data.)

Population — Bureau of the Census. Statistical Abstract of the United States 1989. Washington, D.C.: U.S. Department of Commerce, 1989.

Figure 3-4. NWS Estimate of Annual Flood-Related Deaths in the United States, 1916-1985.



NOTE: Date shown is the last year of the five-year period.

Sources: Damages — National Weather Service, Silver Spring, Maryland.

Population — Bureau of the Census. Statistical Abstract of the United States 1989. Washington, D.C.: U.S. Department of Commerce, 1989.

Figure 3-5. NWS Estimate of Annual Flood Damages in the United States, 1916-1985.

On the other hand, there has definitely been an increase in flood damages over the 70 year period. The average annual damages in the period from 1916 to 1960 are 268 percent greater in constant 1985 dollars than the period from 1951 to 1985 — an increase from $592 million to $2.18 billion. With the adjustment for population, the average annual damages for the same periods are $902 million and $2.15 billion, an increase of 139 percent. In other words, per capita flood damages were almost 2.5 times as great from 1951 through 1985 as they were from 1916 through 1950, after adjusting for inflation. There were 22 years in the second half of the period with more than one billion dollars damage, compared with ten during the first half.

Research based upon NWS survey reports (which cover events that claim 3 or more lives or cause more than $100 million in property damages) gives an annual death rate of 91.5 for the thirteen years from 1969 through 1981. During that period, the highest average number of deaths per event was associated with dam failures. Ninety-three per cent of the deaths were due to drowning, and 42 per cent of the drownings were car-related (French, 1983). It should be noted that neither of these references include smaller flood events, which may account for many flash flood deaths.

The American National Red Cross also provides data on lives lost and dwellings damaged or destroyed due to disasters. Tables 3-9 to 3-11 show estimates, based on data collected by the Red Cross, from 1965 to 1985 for hurricanes, storms and floods (Rubin, 1986).[5] A comparison of the lives lost in the estimates developed by the NWS and the Red Cross show marked differences in many instances. Differences are due in part to procedures for collecting data, including differences in the flood events for which data are collected. In either case, it is not clear which figures are solely flood-related and which include wind and other hazards. There are also inconsistencies between the annual deaths reported in the Red Cross data and the deaths that have been attributed by other sources to specific flood events as reported in Appendix A of the *Assessment Report*.

Table 3-12 shows the number of deaths attributed to floods and storms[6] annually from 1965 through 1985 based on Red Cross data. According to Table 3-12, the average annual deaths due to floods and storms from 1965-66 through 1984-85 (based on fiscal year of July 1 - June 30) is 119.4 (Rubin, 1986). The NWS data from Table 3-7 indicate an annual average of 157.7 flood-related deaths for the period 1966-1985 (based on fiscal year of October 1 - September 30). This difference of 32 percent is an indication of the problems in flood loss data.

Another measure of flood losses is the number of major (Presidential) disaster declarations and the amount of federal disaster assistance provided to individuals and communities for these disaster events. Table 3-13 shows a total of $6.767 billion in disaster assistance from 1965 through 1989, with $5.206 billion, or 77 percent, for flood related (including hurricane-related) damages (Federal Emergency Management Agency, 1985, 1990). Table 3-13 lists only disaster assistance payments authorized through the President's Disaster Relief Fund. It is not an estimate of total damages, nor does it include several other forms of financial protection and aid provided by other federal agencies, state and local governments, and private organizations.

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5 The differentiation between hurricanes, floods and storms is made by the American National Red Cross, which is the source of the data used by Claire Rubin (George Washington University) to produce the tables.

6 Not all deaths attributed to floods and storms are due to drowning. Floods may cause behavior that directly results in death by heart attack, electrocution, and various sorts of traumatic injuries.

Table 3-9. Hurricanes: Deaths, Injuries, and Damage to Dwellings, 1965-1985. (Based on American National Red Cross Data.)

FISCAL YEAR	NO. OF EVENTS	PERSONS KILLED	PERSONS INJURED	DWELLINGS DESTROYED	DWELLINGS DAMAGED	DWELLINGS DESTROYED & DAMAGED
1965-66	5	72	25,202	2,059	148,607	150,66
1966-67	NA	0	13	6	316	322
1967-68	NA	19	11,396	388	29,405	29,793
1968-69	NA	2	45	1	705	706
1969-70	NA	272	9,062	6,046	48,734	54,780
1970-71	5	9	4,498	1,887	34,442	36,329
1971-72	4	2	235	36	24,258	24,294
1972-73	0	0	0	0	0	0
1973-74	0	0	0	0	0	0
1974-75	2	3	8	45	2,514	2,559
1975-76	3	32	4,409	4,642	31,670	36,312
1976-77	1	2	23	15	498	513
1977-78	3	0	8	6	142	148
1978-79	1	0	0	1	3	4
1979-80	6	20	6,765	6,897	65,033	71,930
1980-81	2	NA	NA	NA	NA	14,865
1981-82	1	0	0	NA	NA	3
1982-83	2	2	961	NA	NA	7,454
1983-84	4	16	3,094	NA	NA	18,663
1984-85	0	0	0	0	0	0
TOTAL	39	451	65,711	22,029	386,327	449,341

Note that these data are presented by fiscal year (July 1 - June 30).

Source: Rubin, Claire B., and others. Summary of Major Natural Disaster Incidents in the U.S. - 1965-85. Natural Hazards Research and Applications Information Center Special Publication 17. Boulder, Colorado: The University of Colorado at Boulder, 1986.

Table 3-10. Storms: Deaths, Injuries, and Damage to Dwellings, 1965-1985. (Based on American National Red Cross Data.)

FISCAL YEAR	NO. OF EVENTS	PERSONS KILLED	PERSONS INJURED	DWELLINGS DESTROYED	DWELLINGS DAMAGED	DWELLINGS DESTROYED & DAMAGED
1965-66	20	42	54	8	1,226	1,234
1966-67	NA	8	43	23	1,723	1,746
1967-68	NA	12	78	298	1,214	1,512
1968-69	NA	51	242	276	11,331	11,607
1969-70	NA	3	22	21	3,950	3,971
1970-71	27	2	71	117	1,207	1,324
1971-72	31	14	1,165	424	9,287	9,711
1972-73	19	1	72	104	4,687	4,791
1973-74	26	8	106	113	1,589	1,702
1974-75	37	7	336	238	7,600	7,838
1975-76	39	44	387	610	28,080	28,690
1976-77	24	54	187	106	2,662	2,768
1977-78	78	164	5,096	476	17,105	17,581
1978-79	80	6	127	144	1,892	2,036
1979-80	56	22	2,995	668	16,285	16,953
1980-81	60	NA	NA	NA	NA	21,885
1981-82	97	24	2,805	NA	NA	10,746
1982-83	55	19	421	NA	NA	6,725
1983-84	71	19	188	NA	NA	5,774
1984-85	11	2	25	NA	NA	438
TOTAL	731	502	14,420	3,626	109,838	159,032

Note that these data are presented by fiscal year (July 1 - June 30).

Source: Rubin, Claire B., and others. Summary of Major Natural Disaster Incidents in the U.S. - 1965-85. Natural Hazards Research and Applications Information Center Special Publication 17. Boulder, Colorado: The University of Colorado at Boulder, 1986.

Table 3-11. Floods: Deaths, Injuries, and Damage to Dwellings, 1965-1985. (Based on American National Red Cross Data.)

FISCAL YEAR	NO. OF EVENTS	PERSONS KILLED	PERSONS INJURED	DWELLINGS DESTROYED	DWELLINGS DAMAGED	DWELLINGS DESTROYED & DAMAGED
1965-66	67	22	102	91	9,131	9,222
1966-67	NA	16	161	108	22,353	22,461
1967-68	NA	38	824	84	14,224	14,308
1968-69	NA	24	284	71	17,674	17,745
1969-70	NA	51	783	83	33,769	33,852
1970-71	49	22	58	105	6,993	7,098
1971-72	77	519	16,587	7,346	133,805	141,151
1972-73	78	105	1,559	3,229	81,467	84,696
1973-74	83	71	366	1,417	31,309	32,726
1974-75	90	48	500	803	25,008	25,811
1975-76	70	55	2,071	1,377	26,179	27,556
1976-77	58	165	1,469	3,581	35,942	39,523
1977-78	106	196	3,712	1,489	48,508	49,997
1978-79	148	143	3,842	2,659	56,646	59,305
1979-80	122	79	1,121	887	37,439	38,326
1980-81	115	NA	NA	NA	NA	19,578
1981-82	133	70	2,561	NA	NA	46,256
1982-83	149	69	1,988	NA	NA	48,874
1983-84	121	65	1,478	NA	NA	41,578
1984-85	48	9	29	NA	NA	2,308
TOTAL	1,514	1,767	39,495	23,330	580,447	762,371

Note that these data are presented by fiscal year (July 1 - June 30).

Source: Rubin, Claire B., and others. Summary of Major Natural Disaster Incidents in the U.S. - 1965-85. Natural Hazards Research and Applications Information Center Special Publication 17. Boulder, Colorado: The University of Colorado at Boulder, 1986.

Table 3-12. Deaths Due to Floods and Storms, 1965-1985. (Based on American National Red Cross Data.)

FISCAL YEAR	NO. OF DEATHS (FLOOD)	NO. OF DEATHS (STORM)	NO. OF DEATHS (TOTAL)	5-YEAR MOVING AVERAGE
1965-66	22	42	64	*64
1966-67	16	8	24	*44
1967-68	38	12	50	*46
1968-69	24	51	75	*53
1969-70	51	3	54	53
1970-71	22	2	24	45
1971-72	519	14	533	147
1972-73	105	1	106	158
1973-74	71	8	79	159
1974-75	48	7	55	159
1975-76	55	44	99	174
1976-77	165	54	219	92
1977-78	196	164	360	162
1978-79	143	6	149	176
1979-80	79	22	101	186
1980-81	NA	NA	NA	*207
1981-82	70	24	94	*176
1982-83	69	19	88	*108
1983-84	65	19	83	*92
1984-85	9	2	11	*39
TOTAL	**1,767	**502	**2,269	
AVERAGE	***93.0	***26.4	***119.4	

Note that these data are for Presidentially declared disasters only.

* Average of four or fewer years through current year.
** Totals for 19 years.
*** Averages for 19 years.

Source: Rubin, Claire B., and others. Summary of Major Natural Disaster Incidents in the U.S. - 1965-85. Natural Hazards Research and Applications Information Center Special Publication 17. Boulder, Colorado: The University of Colorado at Boulder, 1986.

Table 3-13. Disaster Assistance Payments for Presidential Disaster Declarations, 1965-1989.

	ALL PRESIDENTIALLY DECLARED DISASTERS		DISASTERS DUE TO FLOODS AND HURRICANES	
DATE	NUMBER	COST	NUMBER	COST
1965	25	88,378,200	17	83,162,400
1966	11	10,765,300	9	6,204,449
1967	11	29,826,100	8	26,558,600
1968	19	14,158,000	13	4,618,891
1969	29	211,839,000	28	211,746,000
1970	17	87,342,400	15	71,561,200
1971	17	236,130,000	11	33,379,300
1972	48	579,304,000	37	81,997,600
1973	46	149,042,000	41	143,547,000
1974	46	135,658,000	33	80,655,700
1975	38	176,912,000	28	161,773,000
1976	29	185,148,000	23	128,675,000
1977	22	397,429,000	16	267,826,000
1978	25	249,048,000	21	244,516,000
1979	42	1,062,430,000	34	490,468,000
1980	23	258,028,000	14	206,235,000
1981	15	40,668,500	11	240,047,000
1982	24	129,986,000	20	117,287,000
1983	21	273,054,000	19	267,759,000
1984	34	164,679,457	26	127,924,700
1985	27	435,336,089	21	406,419,123
1986	28	176,637,486	24	172,803,240
1987	23	154,035,433	17	140,265,115
1988	11	27,712,811	5	24,458,312
1989	26	1,493,890,000	17	1,465,650,000
TOTAL	657	6,767,440,000	508	5,205,540,000

Sources: Federal Emergency Management Agency. "DMIS Reports for Major Disasters and Emergencies, 1953-1984." FEMA, 1985; Federal Emergency Management Agency. "DMIS Report 24: President's Fund: Actual and Projected Obligations; Major Disasters; Period of Declarations: 83/10/01 - 90/07/31." July 1990.

Among the other forms of financial protection and aid administered by federal agencies are: flood insurance administered by the Federal Insurance Administration to partly indemnify public and private flood losses; aid provided by the Federal Highway Administration (FHWA) to state and local governments (and other federal agencies) to repair or replace roads and bridges that are part of the Federal-Aid Highway Program; loans to individuals and businesses from the Small Business Administration (SBA); and aid to farmers from the U.S. Department of Agriculture (USDA). During the 10-year period from 1978-1987, a total of $2.658 billion in flood insurance claims were paid out by the NFIP (Flood Insurance Producers National Committee, 1988). Information on financial aid provided by other agencies is not readily available in a form that separates flood-related damages from other types of natural and technological disasters. In most years, however, flood damages constitute the bulk of other federal financial aid for disasters. The FHWA provided a total of $442.3

million in emergency relief during the four fiscal years 1986-1989 (Federal Highway Administration, 1990). In fiscal year 1989, the SBA issued $78.76 million in Economic Injury Disaster Loans and $67.96 million in Physical Disaster Loans (U.S. General Services Administration, 1990).[7]

LOSSES IN COASTAL AREAS

Flood-caused losses in coastal areas can be attributed to hurricanes and coastal storms, shoreline erosion, and tsunamis.

Hurricanes and Coastal Storms

Although wind is the element most commonly associated with hurricanes by the public, damages from hurricanes are caused by inundation, storm surge, waves and erosion, as well as high winds. Despite the public perception of winds as the major danger from hurricanes, most hurricane-related deaths have been caused by storm surge.[8]

Average annual property losses due to hurricanes rose from $250 million during the decade between 1951 and 1960 to over $400 million in the decade between 1961 and 1970. There has been at least one landfalling hurricane in the United States each year since 1982. Hurricane Alicia in 1983 caused over $750 million in damages to commercial, residential and public facilities in the Galveston, Texas area. In 1985, six hurricanes tore through 10 states along the Gulf and Atlantic coasts, leaving 30 dead and more than $4 billion in damages to homes, businesses and public facilities. Hurricanes Danny, Elena, Gloria, Juan, and Kate resulted in an estimated $1 billion in federal assistance on the Atlantic and Gulf coasts in 1985. Only two hurricanes, Bonnie and Charley, made landfall in 1986, causing eight deaths and an estimated $16.4 million in damage. Only one hurricane affected the U.S. in each of the years 1987 and 1988. In 1989, hurricanes Chantal, Hugo and Jerry made landfall (Jarvinen, 1990). Hurricane Hugo, which crossed inland over Charleston, South Carolina, earned the distinction of being the most costly hurricane in the Nation's history, with total damage estimates as high as $10 billion (Duryee, 1990).

From 1981 to 1985, about 23% (16 of 67) of all Presidentially declared disasters involved coastal flooding and about 49% ($265 of $539 million) of federal disaster aid obligations were attributable to coastal damage. Of the total 2 million eligible properties and $150 billion of coverage provided during that time through the National Flood Insurance Program, about 70% of the properties were in coastal communities (cities, towns and counties having a portion of their areas on the coast). As noted earlier, there is no means of separating flood damages from other hurricane damages. There is also no direct means of separating coastal damages from inland (riverine) damages that result from hurricanes.

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7 Refer to Chapter 13 for further information on flood insurance claims and payments and the various types of disaster assistance.

8 See Figure 1-8 for a description of the types of damages associated with winds of increasing intensity during a hurricane.

Shoreline Erosion

A national assessment of shore erosion was conducted by the Corps of Engineers in 1971, resulting in an 11-volume report, *The National Shoreline Study* (U.S. Army Corps of Engineers, 1971). The Corps found that of the total 84,240 miles of the Nation's shoreline, 20,500 miles or about 24 percent were significantly eroding. Table 3-14 details erosion estimates for the Great Lakes, Alaska and other ocean shoreline. The 2,700 miles of critically eroding shoreline were prioritized according to the need for addressing erosion problems:

- FIRST PRIORITY: 200 miles where, if erosion continued, public safety would be endangered within 5 years.
- SECOND PRIORITY: 1,000 miles where property or scarce wildlife habitat or important natural landmarks would be endangered within 5 years.
- THIRD PRIORITY: the remaining 1,500 miles.

Table 3-14. Status of Coastal Erosion in the United States, 1971.

	TOTAL SHORE MILES	CRITICAL EROSION MILES	NON CRITICAL MILES	TOTAL MILES SIGNIF. EROSION	PERCENT ERODING SIGNIFICANTLY
Great Lakes	3,680	220	1,040	1,260	34%
Oceanic, Except Alaska	33,260	2,380	11,760	14,140	43%
Alaska Only	47,300	100	5,000	5,100	11%
TOTAL	84,240	2,700	17,800	20,500	24%

Source: U.S. Army Corps of Engineers. Report on the National Shoreline Study. 1971 (p.18).

Estimates on ownership of the critically eroding shoreline indicated that 1,810 miles (67 percent) were in private ownership, 340 miles (13 percent) were in federal ownership, and 480 miles (20 percent) were nonfederal, publicly owned shoreline.

No more recent comprehensive study of shoreline erosion has been performed. The Corps considers the results of the 1971 study to still be a good estimate of the extent of the shoreline erosion problem (Schilling, 1987).

Erosion along the shores of the Great Lakes increases during periods of abnormally high lake levels, such as most recently occurred during the mid-1980s. During high water periods, erosion accelerates and may continue for several years after lake levels recede as the bluff slopes reach equilibrium with the new conditions (Horvath, 1989).

Tsunamis

In recent times, three tsunamis have caused major destruction in areas of the United States. The Great Aleutian tsunami of April 1, 1946 killed 173 persons in Hawaii,[9] where heights as great as 55 feet were recorded. The first waves arrived about five hours after the quake occurred in the Aleutian Trench, about 2,240 miles north of Hawaii, indicating a speed of about 490 miles per hour for the waves. Most affected areas in Hawaii experienced a series of waves ranging from 20 to 50 feet in height, although in some areas damage resulted primarily from the initial violent draw-down of water to the sea. This tsunami was particularly important because it spurred development of a tsunami warning service.

A May 22, 1960 earthquake off the coast of Chile generated a tsunami which killed 61 people in Hawaii,[10] mostly in Hilo (in addition to 330 in Chile and 199 in Japan). A tsunami warning was issued at Honolulu 12 hours before the first waves arrived, but many people ignored the warning, grew tired of waiting on high ground, or stayed behind to see the predicted wave.

The most recent major tsunami to affect the United States — generated by the "Good Friday" earthquake of March 27, 1964 — killed 107 people in Alaska, 4 in Oregon, and 11 in Crescent City, California, and caused over 100 million dollars in damage on the west coast of North America.[11] Adequate warnings were not provided for this tsunami because the earthquake was centered in Prince William Sound, only a short distance from where the tsunami hit in Alaska, and communications systems were disrupted. This tsunami resulted in the establishment of regional tsunami warning systems for Alaska and for the Hawaiian Islands (Houston, 1980; Forrester, 1987).

LOSSES DUE TO FAILURES OF FLOOD CONTROL STRUCTURES

Some of the most significant losses due to the failure of flood control structures can be attributed to the failures of levees and dams.

Losses Due to Levee Failure

Levees are the most common type of flood control works, with an estimated 25,000 miles of levees constructed nationwide. Many private or locally built levees provide only limited flood protection or are poorly designed and maintained (including some private levees with no design standards at all). Although many of the Nation's levees protect agricultural rather than urban development, levee overtopping or failure reportedly is involved in approximately one-third of all flood disasters (Federal Emergency Management Agency, 1987).

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9 These deaths are not reflected in Table 3-7 because Hawaii was not a state at that time.

10 These deaths are not reflected in the data presented in Table 3-7 for unknown reasons.

11 These figures cannot be reconciled with the data presented in Table 3-7.

Losses Due to Dam Failures

Although significant advances in design and construction techniques have been made, larger dams are being built and the impoundment of water is never without risk. The possibility of dam failure due to structural failure, earthquakes or sabotage, for example, remains, despite increased attention to safer design, construction and maintenance.

Damage from dam failure is severe because of the unexpectedness and high velocity of flood water. Breaching often occurs within hours after the first visible signs of dam failure, leaving little time for warning and evacuation.

Failure of a dam may subject more people and property to flooding than would occur due to flooding without the dam failure. For example, the flood at Rapid City, South Dakota in 1972 that killed 242 people also caused a dam failure that added to the loss of life. The sudden surge of water resulting from a dam failure is likely to inundate a larger area than delineated by the one percent annual chance ("100-year") floodplain. This sudden surge of water may also be powerful enough to destroy other downstream dams, as occurred during floods on the Falls River in Essex, Connecticut in June 1982 (L.R. Johnston Associates, 1983). Table 3-15 lists loss of life and property damage from several notable dam failures from 1963 to 1990 (Colorado Division of Disaster Emergency Services, 1987, updated by Wayne Graham, Bureau of Reclamation, 1991).

Dam failure may occur for many reasons, both structural and nonstructural. Many sources of dam failure can be traced to decisions made during design and construction and to inadequate maintenance or operational mismanagement. Failures may also result from other natural hazards such as earthquakes and flow volumes exceeding design capacity (Colorado Division of Disaster Emergency Services, 1987). Figures 3-6 and 3-7 show causes of failure (based on studies by the International Commission on Large Dams (ICOLD)) of dams more than 15 feet high when failure resulted in downstream water releases.

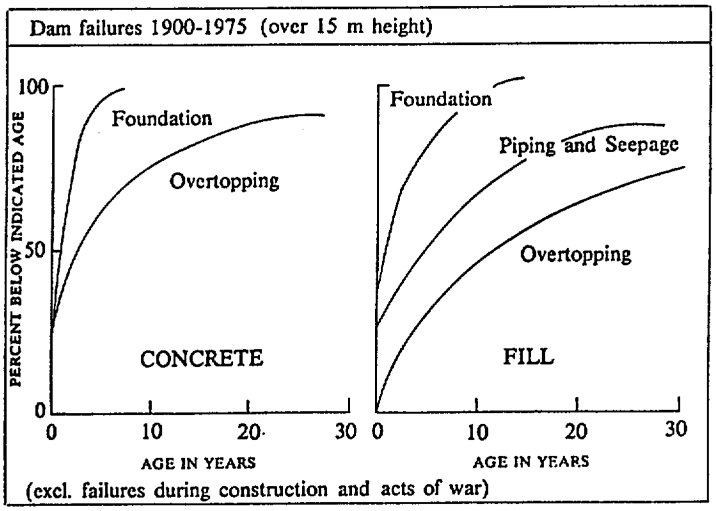
LOSSES DUE TO FLASH FLOODS

A report prepared for FEMA in 1985 (Federal Emergency Management Agency, 1987) estimated that damages caused by flash floods had doubled in the previous ten years. It found that over three-quarters of all Presidentially declared disasters involve flash flooding and that flash floods were the greatest cause of weather-related deaths in the United States until the 1980s. Examples of recent flash floods, accounting for 645 deaths from 1972 to 1977, are shown in Table 3-16.

Table 3-15. Loss of Life and Property Damage From Notable U.S. Dam Failures, 1963-1990.

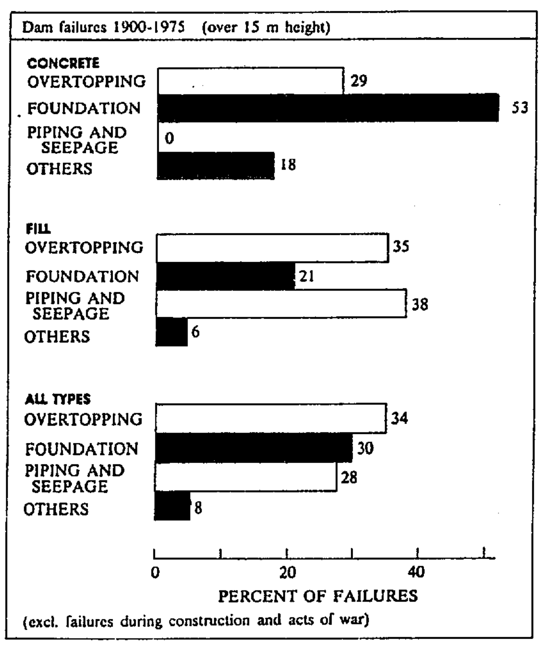
NAME & LOCATION OF DAM	DATE OF FAILURE	NUMBER OF LIVES LOST	DIRECT DAMAGES
Mohegan Park, CT	March 1963	6	$3 million
Little Deer Creek, UT	June 1963	1	Summer cabins damaged
Baldwin Hills, CA	December 1963	5	41 houses destroyed, 986 houses damaged, 100 apartment buildings damaged
Swift, MT	June 1964	19	Unknown
Lower Two Medicine, MT	June 1964	9	Unknown
Lee Lake, MA	March 1968	2	6 houses destroyed, 20 houses damaged, 1 manufacturing plant damaged or destroyed
Buffalo Creek, WV	February 1972	125	546 houses destroyed, 538 houses damaged
Lake "O" Hills, AK	April 1972	1	Unknown
Canyon Lakes, SD	June 1972	33	Unable to assess damage because dam failure accompanied damage caused by natural flooding
Bear Wallow, NC	February 1976	4	1 house destroyed
Teton, ID	June 1976	11	771 houses destroyed, 3,002 houses damaged, 246 businesses damaged or destroyed
Laurel Run, PA	July 1977	40	6 houses destroyed, 19 houses damaged
Sandy Run and 5 others, PA	July 1977	5	Unknown
Kelly Barnes, GA	November 1977	39	9 houses, 18 house trailers and 2 college buildings destroyed; 6 houses, 5 college buildings damaged.
Swimming Pool, NY	1979	4	Unknown.
About 20 dams in CT	June 1982	0	Unknown.
Lawn Lake, CO	July 1982	3	18 bridges destroyed, 117 businesses and 108 houses damaged, campgrounds, fisheries, power plant damaged.
DMAD, UT	June 1983	1	Unknown.

Source: Colorado Division of Disaster Emergency Services. Dam Safety: An Owner's Guidance Manual FEMA 145. Washington, D.C.: Federal Emergency Management Agency, 1987. Updated by Wayne Graham, Bureau of Reclamation, 1991.



Source: Colorado Division of Disaster Emergency Services. Dam Safety: An Owner's Guidance Manual FEMA 145. Washington, D.C.: Federal Emergency Management Agency, 1987.

Figure 3-6. Age of Dams at Time of Failure.



Source: Colorado Division of Disaster Emergency Services. Dam Safety: An Owner's Guidance Manual FEMA 145. Washington, D.C.: Federal Emergency Management Agency, 1987.

Figure 3-7. Causes of Dam Failure.

Table 3-16. Examples of Flash Floods Causing Serious Loss of Life.

FEBRUARY 1972, BUFFALO CREEK, WEST VIRGINIA: 125 killed and hundreds of homes washed away as a dam made of coal mine waste material gave way after heavy rains.

JUNE 1972, RAPID CITY, SOUTH DAKOTA AND ADJACENT AREAS: 236 dead and $100 million in property damage after a large, slow-moving thunderstorm unleashed torrents of rain on the slopes of the Black Hills. Flood resulted in the failure of Canyon Lake Dam.

JULY, 1976, BIG THOMPSON CANYON, COLORADO: 139 killed and millions in property damage after a thunderstorm deluged the western third of the canyon with 12 inches of rain in less than 6 hours.

JULY, 1977, JOHNSTOWN, PENNSYLVANIA: 77 dead and more than $200 million in property damage when violent thunderstorms caused up to 11 inches of rain to fall in a 7-county area over 9 hours. This contributed to the failure of several dams which compounded the stream flooding and accounted for 45 of the deaths.

SEPTEMBER, 1977, KANSAS CITY, MISSOURI AND ADJACENT AREAS: 25 killed and $90 million in property damage when thunderstorms turned several streams into raging torrents, such as the "gentle" Brush Creek, which flows through the heart of Kansas City.

Source: Federal Emergency Management Agency. Reducing Losses in High Risk Flood Hazard Areas: A Guidebook for Local Officials FEMA 116. Washington, D.C.: FEMA, 1987.

LOSSES DUE TO STREAMBANK EROSION

A nationwide study of streambank erosion (U.S. Army Corps of Engineers, 1981)[12] estimated $295 million (1985 dollars) in average annual damages due to streambank erosion. This study included direct and indirect loss of income, increased costs and reduction of environmental quality as damages. The Corps estimated that there are 7 million miles of streambank (3.5 million stream miles). Of this 7 million miles of streambank, 574,500 miles have erosion problems, but only 142,100 miles have serious erosion problems. About 78 percent of all streambank erosion takes place west of the main stem of the Mississippi River. Table 3-17 displays erosion estimates by regions.

LOSSES DUE TO GROUND FAILURE

Losses from landslides in the United States are estimated at $1 to $2 billion and 25 to 50 deaths each year (National Research Council, 1985). Application of a U.S. Geological Survey method for estimating the cost of landslide damage indicates that not only are reported costs much lower than those actually incurred, but that losses are on the increase in most regions. In the 1964 Alaska earthquake in Prince William Sound, 60% of the $500 million in damages was due to ground failure (Federal Emergency Management Agency, 1987).

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[12] The Corps' study found that average annual damages totalled about $295 million (1985 dollars) for the 142,000 miles of river banks with the most severe erosion problems, while the costs to prevent that erosion was about $1.3 billion (1985 dollars). It concludes that stream reaches for which erosion control measures are likely to be economically justified "...will be widely scattered and located in substantially populated and developed areas... or near bridges or other structures" (U.S. Army Corps of Engineers, 1981).

Table 3-17. National Assessment of Streambank Erosion.

REGION	STREAM-MILES	EROSION BANK-MILES	SEVERE EROSION BANK-MILES	AVERAGE ANNUAL DAMAGES (1,000) (1981 $)	(1985 $)
Alaska	568,000	58,000	<50	1,000	1,200
Arkansas-White-Red	218,000	56,500	22,800	79,000	93,500
California	133,000	50,600	8,100	47,500	56,200
Pacific-Northwest	345,400	33,600	21,200	19,900	23,600
Colorado	295,900	24,600	3,900	4,100	4,800
Great Basin	152,700	5,000	300	400	500
Great Lakes	66,100	9,100	4,500	2,300	2,700
Hawaii	2,600	0	0	0	0
Lower Mississippi	88,400	15,500	12,700	32,900	38,900
Middle Atlantic	95,700	28,500	8,000	9,200	10,900
Missouri Basin	538,200	52,800	11,800	14,200	16,800
New England	48,200	1,900	400	1,500	1,800
Ohio	147,200	27,300	6,800	4,800	5,700
Rio Grande	101,800	54,800	7,100	8,900	10,500
Souris-Red-Rainy	67,200	1,200	100	1,000	1,200
South Atlantic Gulf	213,300	37,900	22,300	10,000	11,800
Tennessee	32,800	4,100	1,700	800	900
Texas Gulf	149,500	98,300	4,300	6,600	7,800
Upper Mississippi	198,200	14,800	6,100	4,900	5,800
U.S. TOTAL	3,462,500	574,500	142,100	$248,800	$294,600

Note: The conversion from 1981 $ to 1985 $ was based on the Consumer Price Index.

Source: U.S. Army Corps of Engineers. Final Report to Congress - The Streambank Control Evaluation and Demonstration Act of 1974 - Section 32, Public Law 93-251, Main Report. Washington, D.C.: U.S. Army Corps of Engineers, 1981.

LOSSES FROM FLUCTUATING LAKE LEVELS

Recent damage estimates indicate that flooding from rising lake levels causes significant economic impacts in the United States. Between 1983 and January 1985, for example, damages resulting from flooding around Lake Malheur, Oregon, had reached $13.5 million. Around the Great Salt Lake in Utah, damages have exceeded $200 million since 1983. Total national losses resulting from fluctuations in lake levels exceeded $250 million between 1981 and 1986 (Federal Emergency Management Agency, 1986).

The extent of these losses is due in large part to the attractiveness of lake shore environments for residential, recreational and other uses. In recent years increased development has occurred on lake shorelines near population centers and major transportation routes because of the aesthetic and recreational values of lakeshores. In Minnesota, for example, between 1967 and 1982 lakeshore homes increased 75%, year round lakeshore use increased 100%, and seasonal lakeshore use increased 63%. In most states lake shore development, principally for year-round or seasonal residential use, has occurred without adequate recognition of the flood hazard and without awareness that water levels can and do vary greatly over time.

LOSSES IN URBANIZING AREAS

Rapidly urbanizing areas are frequently affected by flooding. Much of the flooding problem in these areas is due to inadequate stormwater drainage rather than classical overbank flooding of streams, although that also can be a problem. As a result, much of this development is not subject to floodplain management regulations. In the Chicago metropolitan area, for example, development of 375 square miles of relatively flat land with a high water table has led to estimated average annual damages of $200 million from sewer backup alone (Dalton, 1987).

FEMA has estimated that from 1978 to 1987, over 31 percent of the total of paid flood insurance claims (106,136 paid losses) was for flooding in areas outside the delineated one percent annual chance floodplain.[13] In addition, 18 percent of the repetitive claims during this period occurred in those areas (Federal Emergency Management Agency, 1988).

LOSSES DUE TO VOLCANIC-INDUCED FLOODING

On May 18, 1980, the catastrophic eruption of Mount St. Helens in Cowlitz County, Washington added a new cause of flood losses in the U.S. Floods and mudflows generated by the eruption caused damages in areas not directly affected by the initial explosion. Three billion cubic yards of debris moved 17 miles down the North Fork Toutle River. The river was swollen by billions of gallons of melting snow and glacial ice and carried the debris as mudflows down the Toutle River into the Cowlitz River and the Columbia River.

> *Along the way, it destroyed homes, washed out roads and bridges, severely damaged public water facilities, buried agricultural lands and clogged the navigation channel. Sediment filled the Cowlitz River, reducing the channel's bankfull capacity by 85%. Mudflow deposits filled low-lying areas that previously functioned as overbank flow and floodwater storage sites. Along the mudflow's 70-mile path, an estimated 150 to 200 million cubic yards of volcanic and landslide material were deposited in the river channels* (Deatherage, 1987).

Costs specifically related to flooding are difficult to determine. Initial damages and cleanup costs (through mid-1987) totalled $1.2 billion. In excess of $875 million is needed to "restore the land, clean up the rivers and provide flood protection to Cowlitz Valley communities" (Cowlitz County Department of Community Development, 1987).

LOSSES TO INFRASTRUCTURE

A recent review (Burby, Undated) of data and previous research relating to losses of infrastructure from natural hazards indicates that damage to infrastructure accounts for about one-sixth to one-quarter of total annual public and private losses. The following studies are cited in this review.

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13 These losses are for areas designated on flood hazard maps as zones B, C, D and X. See Chapter 13 for further description of flood insurance policy and claims data.

A review (Dacy and Kunreuther) of eight disasters occurring in the 1950s and 1960s found damage to public facilities at about 25 percent (median) of total damages, with a range from 7 percent to 70 percent. In the Minnesota River Basin between 1965 and 1970, losses to public facilities ranged from 10 to 15 percent of total damages. A report for the Federal Insurance Administration (FIA) (Sheaffer, 1976) calculated annual flood damages to infrastructure (highways, bridges, culverts, water supply and sewerage systems) at 19 percent of total flood damages. In urban areas up to 25 percent of total damages were to infrastructure. A later study of 23 communities by the same group estimated average annual losses to infrastructure from flooding at $520 per acre. Another more recent study estimated that natural hazards cause over $1 billion (1970 dollars; $2.8 billion 1985 dollars)) in losses to public facilities each year. Infrastructure losses were distributed among: public utilities ($403.5 million ($1.12 billion 1985 dollars)); highways, streets and bridges ($351.3 million ($973.4 million 1985 dollars)); and water supply and sewerage systems (136.2 million ($377.4 million 1985 dollars)).

These reports and estimates of losses to infrastructure seem reasonable considering that site development costs (roads, utilities, landscaping, etc.) typically average about 15 percent of total development costs, and that approximately 25 percent of the structural wealth of the Nation consists of public utilities, highways and streets, and water supply and sewerage systems (Burby, Undated).

LOSSES TO AGRICULTURE

According to the 1982 National Resources Inventory (NRI) conducted by the SCS, cropland, pasture, range land, and forest land comprise over 90 percent of the total rural, nonfederal floodplain land in the United States. The 1975 Second National Water Assessment (U.S. Water Resources Council, 1977) estimated that 50 percent of annual flood damages affect the agricultural sector.

On irrigated cropland, flooding can damage expensive irrigation facilities such as ditches, pipelines and sprinklers. Sediment deposited by flood waters can cause two types of damage on cropland. One is the long-term loss in yield associated with the deposition of relatively infertile material on good agricultural land. The value of this loss has not been estimated. The other type of loss is damage to the current crop that occurs when sediment buries growing crops or covers plants with a thin film of sediment that interferes with growth of the crops. The amount of this damage ranges from $5 to $40 per acre of flooded cropland, averaging about $20 per acre. Data from SCS watershed protection projects and river basin studies indicates that about 9.1 million acres of floodprone cropland are damaged by sediment each year. Nationwide, the loss of production caused by sediment deposition ranges from $150 to $500 million annually (U.S. Department of Agriculture, 1989).

RELATIVE FLOOD LOSSES OVER TIME

It is useful to examine flood losses in the context of changes over time, to look at how flood losses compare to losses from other types of natural disasters, and to look at what these losses mean in terms of the overall growth and development of the Nation.

LOSS OF LIFE FROM FLOODS

As noted earlier in this chapter, data from the NWS (Table 3-7 and Figure 3-4) indicate no clear trend in the average annual number of deaths due to flooding. Others have noted that there appears to be no clear relationship between property damage and the number of deaths. Flood-related deaths appeared to be at a slow increase or stationary, between 2.5 and 5.8 per 10 million population, with the exception of three five-year periods (White, 1976). Cassidy (1962) noted that the number of flood events causing a large loss of life has decreased: "Between 1900 and 1940, when the Federal flood control program first began to be effective, floods causing the loss of 100 lives or more occurred on the average of about once every three years, but since 1940 the frequency of such floods has averaged only about once in ten years."

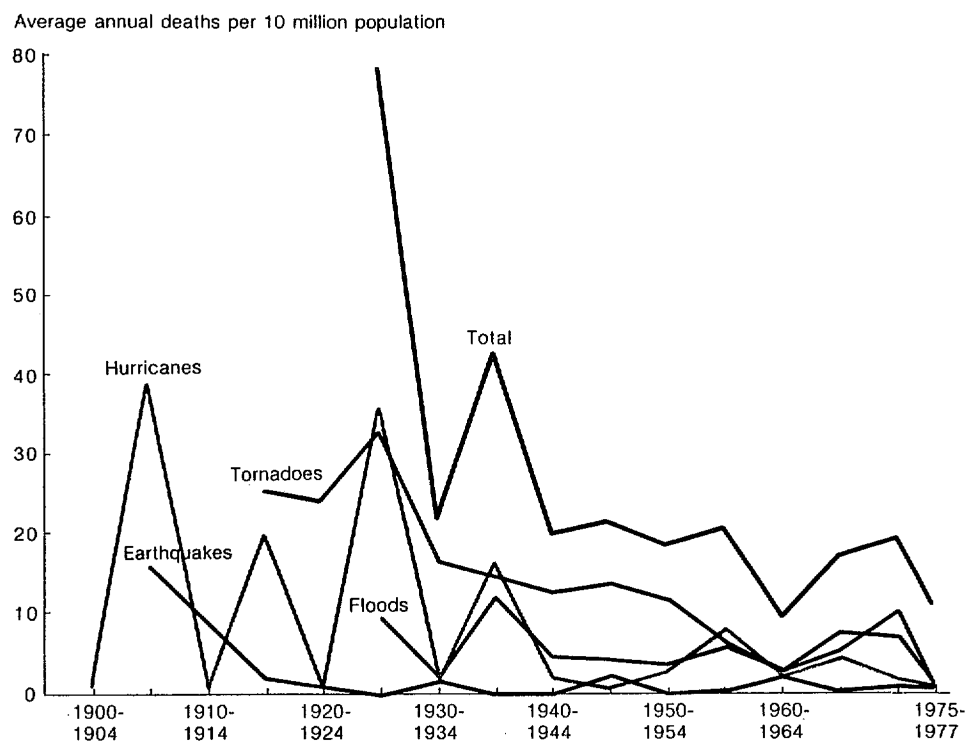
The Council on Environmental Quality (CEQ) (1981) reviewed loss of life and property damage from four types of natural disasters — floods, hurricanes, tornadoes, and earthquakes — from 1900 through 1977 (Council on Environmental Quality, 1981). The CEQ noted that deaths from natural disasters declined over the last 50 years of this period (see Figure 3-8). Major trends observed by CEQ were: 1) the wide fluctuations in the number of hurricane-caused deaths that characterized the first half of the century had been narrowed; 2) large losses of life from tornadoes — consistently the major cause of death from natural disasters through much of the century — had dropped from 30 per 10 million population in the 1920s to fewer than 10 per 10 million in the 1960s and 1970s; and 3) loss of life from floods had not declined.

PROPERTY DAMAGES FROM FLOODS

Cassidy (1962) also analyzed property damage caused by very large floods.

> *... whereas [great] floods causing property damage of $50,000,000 or more (1959 dollars) occurred with a frequency of about once every six years during the period between 1900 and 1940, floods causing this amount of damage have occurred on an average of once in less than two years since 1940. As this increasing frequency of floods causing major property damage is not caused by an increase in the magnitude of flood flows, it must be explained on the basis of the other component of the flood problem — that is, an increasing encroachment on the flood plains.*

The CEQ (1981) found that property damage from the four types of natural disasters which it examined had increased over the 50 year period from 1927 to 1977. Floods were noted as the major cause of property and crop losses. The NWS data presented in Table 3-8 and Figure 3-5 indicate an increase in flood damages (in constant 1985 dollars) over a 70 year period.



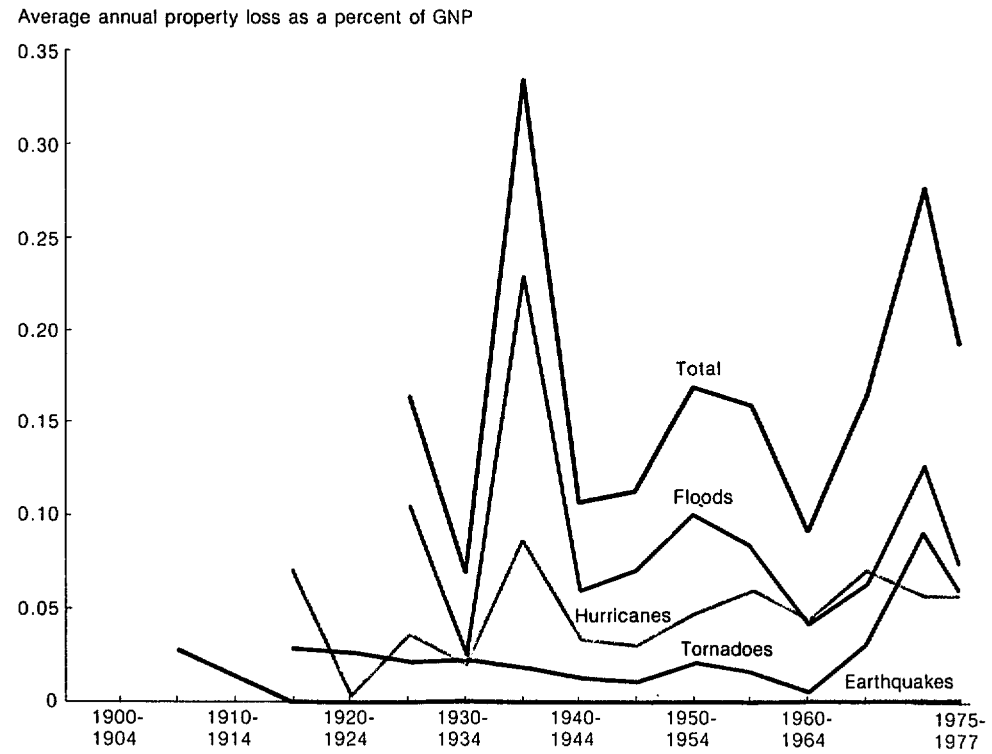
Source: Council on Environmental Quality. Environmental Trends. Washington, D.C.: U.S. Government Printing Office, 1981.

Figure 3-8. Loss of Life from Selected Natural Disasters, 1900-1977.

FLOODS LOSSES AND THE NATIONAL ECONOMY

Much of the data on flood losses has been reported as if development and economic factors were static. Consequently, much of the literature contains statements on ever-increasing flood losses despite the vast sums of money that have been invested in structural flood control measures and, more recently, in nonstructural measures as well. Reports of flood losses should be examined within the context of the Nation's economic conditions, with attention given to population, the amount of housing stock and other development, and inflation conditions. Population, for example, has nearly doubled since 1930, resulting in increased use of previously undeveloped land. Also, as the economy has grown over the years, the value of land, including land subject to flooding, has grown. In addition, "the general increase in prices has, by itself, caused damages measured in current dollar terms to rise significantly. There has been a six-fold increase in prices since 1930, and between 1967 and 1986 prices tripled" (Woolley, 1986).

While there appears to have been little compilation of information pertaining to flood losses and the national economy, that which is available indicates that property losses from floods have remained relatively constant when viewed in the context of the overall national economy. The CEQ (1981) noted that for the late 1970s, the average annual loss from the four types of natural disasters it examined (Figure 3-9) was estimated at $3.2 billion, about 0.2 percent of the Gross National Product (GNP) at that time. (The GNP may be the best measure of the Nation's total wealth.) Losses had not grown in terms of the overall productive capacity of society, measured by the average annual dollar loss as a percentage of GNP.



Source: Council on Environmental Quality. Environmental Trends. Washington, D.C.: U.S. Government Printing Office, 1981.

Figure 3-9. Property Damages from Selected Natural Disasters, 1900-1977.

A more recent study (Woolley, 1986) also examined flood losses as a percentage of the GNP. By comparing annual flood losses as a percentage of annual GNP from 1929 to 1983, large fluctuations from year to year are clearly evident, but there appears to be no significant trend of a decrease or increase in relative flood losses. To illustrate how deceptive simple dollar figures can be, Woolley noted that approximately $440 million of damages due to flooding in the Ohio and Lower Mississippi River basins in 1937 amounted to .0049% of GNP for 1937. In contrast, damages in 1983 amounted to over $4 billion, but represented only .0012% of GNP. Overall, relative flood damage appears to have remained, on the average, basically constant during this period.

ESTIMATES OF FUTURE FLOOD LOSSES

Projections of future flood losses have been made from time to time by various individuals and groups. Most of these projections appear to be simply linear extrapolations based on recent loss estimates. By far the most systematic and ambitious effort at projecting flood losses was made in 1976 under the auspices of the U.S. Water Resources Council. As part of the 1975 National Water Assessment, a Flooding Technical Committee prepared a report of *Estimated Flood Damages* (U.S. Water Resources Council, 1977). This report developed estimates of average annual flood damages for the years 1985 and 2000.

Damage estimates were made for both upstream and downstream areas for each of the standard water resource regions recognized by the WRC. Upstream refers to drainage areas of less than 400 square miles, while downstream refers to drainage areas generally exceeding 400 square miles. Damage estimates were developed for three categories within both upstream and downstream areas: 1) urban and built-up; 2) agricultural; and 3) other (including rural utilities, roads and railways, homesteads, forest and grasslands, refuges, and parks). The Flooding Technical Committee projected damages based on four alternative levels of floodplain management: 1) floodplain management to remain constant (as it was in 1975); 2) floodplain regulation adoption rate to continue; 3) regulate floodplain to the maximum practical extent; and 4) present trend in regulatory measures will accelerate and structural measures will be installed at a slower rate. The fourth alternative was selected as the one most likely to occur, and was referred to as the "Modified Central Case." Table 3-18 shows the projections for each alternative, and Figure 3-10 displays projected upstream and downstream damages for the selected alternative by water resource regions.

Table 3-18. WRC Projections of Future Flood Losses.

	PROJECTED LOSSES (Million 1985 $)					
FUTURE ALTERNATIVES (POLICY AND/OR CASES)	URBAN & BUILT-UP	AGRICUL-TURE	OTHER	TOTAL	UPSTREAM	DOWN-STREAM
1985						
Floodplain management to remain constant	3,161	3,526	1,792	8,479	3,970	4,509
Current trends in increased regulations to continue	2,894	3,526	1,676	8,095	3,822	4,273
Maximum practical regulation	2,743	.3,526	1,676	7,944	3,732	4,212
Modified Central Case	2,772	3,384	1,608	7,763	3,671	4,093
2000						
Floodplain management to remain constant	4,544	4,080	2,649	11,273	5,562	5,711
Current trends in increased regulation to continue	3,880	4,086	2,375	10,342	5,063	5,279
Maximum practical regulation	3,010	4,086	2,330	9,426	4,405	5,021
Modified Central Case	3,352	3,677	2,111	9,140	4,557	4,583

Source: U.S. Water Resource Council. Estimated Flood Damages. Appendix B: Nationwide Analysis Report. U.S. Water Resources Council, 1977.

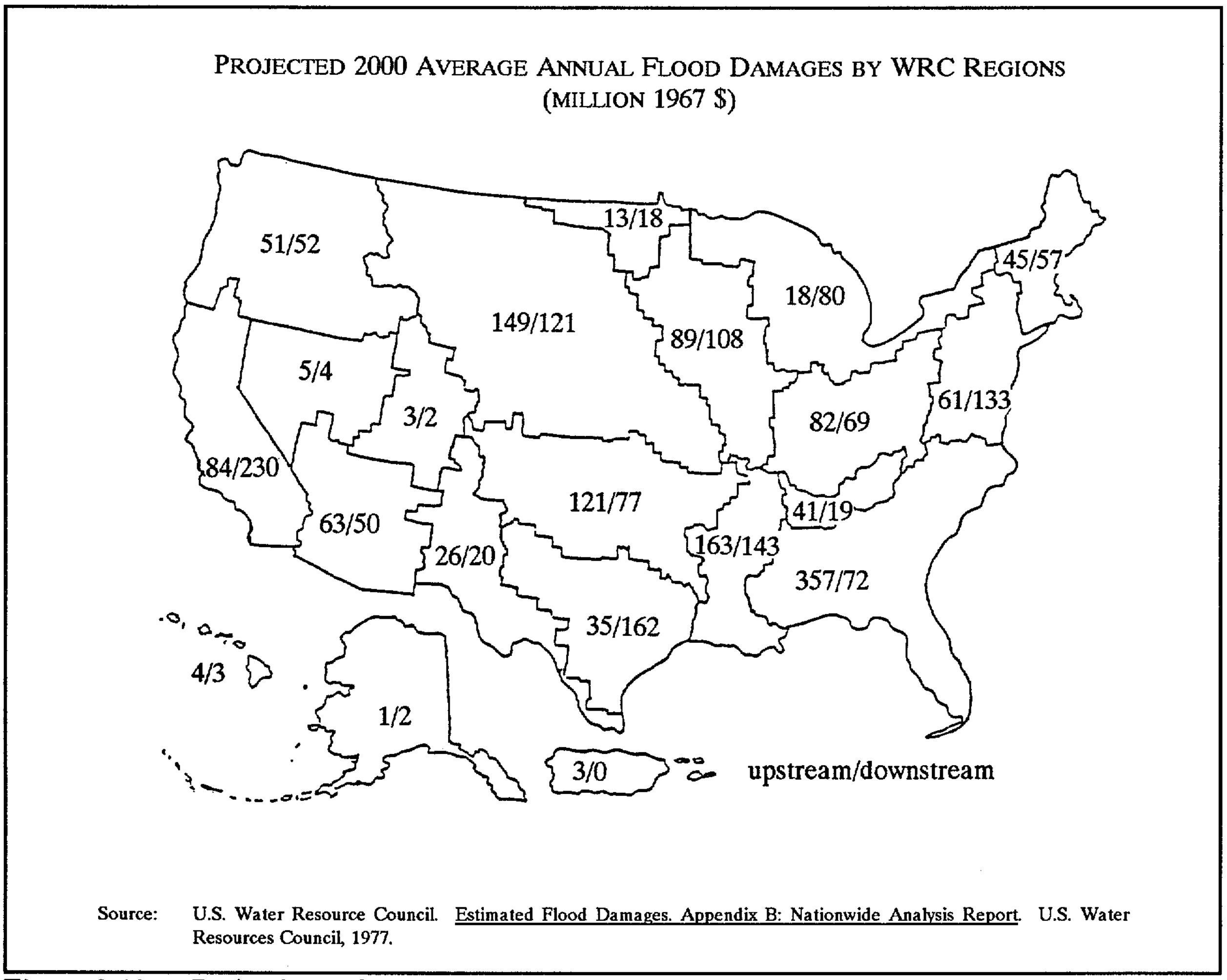


Figure 3-10. Projections of Future Flood Losses.

SUMMARY AND CONCLUSIONS

Floodplain losses are of two types: 1) loss of natural and cultural resources, and 2) loss of life and loss of property. Both types of losses continue to occur even with increased awareness of floodplain values and of the risks of floodplain occupancy. Actual and relative amounts of these losses, however, are not well quantified. Loss of wetlands and riparian habitat are difficult to measure for many reasons, including differing definitions and survey techniques. Available data seems to indicate that increased awareness and regulatory programs have slowed the rate of loss from the very high levels that prevailed during much of the Nation's history. Nevertheless, current loss rates appear to remain at unacceptable levels that, if continued, would greatly reduce the limited remaining areas of these valuable resources.

Loss of life and property continue at high levels, with floods accounting for the greatest losses of any type of natural disaster in the United States. Two trends appear clear: 1) on a per capita basis, loss of life appears to have been relatively constant throughout this century; and 2) the dollar value of property losses (and other economic losses) continues to escalate. Much less clear is the significance of the dollar loss relative to other factors. Although the per capita costs of flood damages have increased significantly, relative to the Gross National Product of the country, economic losses from floods appear to have held quite constant over the past 50 years. Consistent, reliable data on historical flood deaths and damages have not been collected and are still not being collected. Detailed analyses of trends will continue to be hampered until such data are collected.

PART II:

THE NATION'S PROGRAM FOR FLOODPLAIN MANAGEMENT

The two chapters that comprise Part II of the *Assessment Report* describe the gradual evolution of early initiatives for flood control into a national program for reducing flood losses and managing the natural and cultural resources of floodplains. Chapter 4 provides an historical overview, describing how management efforts have shifted from the early emphasis on controlling floods with structural measures during most of this century, to the current approach that involves a mix of both structural and nonstructural measures as well as efforts to protect and restore floodplain natural functions. Chapter 5 provides a detailed description of House Document 465, *A Unified National Program for Managing Flood Losses*, which in 1966 set out the initial concept of a unified national program for reducing flood losses. This concept was refined and expanded over the next 20 years and described in three different versions of *A Unified National Program for Floodplain Management*. This Unified National Program established a basic goal of wise use of the floodplain, set forth several concepts of floodplain management, and identified implementing strategies and tools.

Floodplain management today is the result of a coalescence of policies for flood control, disaster assistance, and protection of the natural environment, and these policies have helped create a strong floodplain management constituency. The current Unified National Program for Floodplain Management provides a conceptual framework for a multi-objective approach to use of the Nation's floodplains and recognition of the respective roles of each level of government and the private sector in the decision-making process.

CHAPTER 4:

HISTORY OF FLOODPLAIN MANAGEMENT

... [I]t is the sense of Congress that flood control on navigable waters or their tributaries is a proper activity of the Federal Government in cooperation with States, their political subdivisions, and localities thereof ...

Flood Control Act of 1936

The history of floodplain management reflects an evolution in federal government policy regarding flood control in general as well as an evolution in the roles of federal, state and local governments in controlling flood losses. The history also reflects a response to much broader trends and attitudes in the United States — with regard to urban growth and development and its consequences, for example, fluctuating levels of government spending, expanding technology, and recognition of the complexity and interrelationship of issues related to land and water uses.

Prior to 1965, governmental actions related to flooding were primarily in response to significant or catastrophic events and sought to control flooding through structural measures. During the mid-1960s, a broadening of federal policy — towards the use of nonstructural means to address flood losses — began to be articulated and formalized. The last 25 years have witnessed a major expansion in the field of floodplain management, including the methods and technologies available for analyzing flooding, attention to floodplain natural resources, as well as shifts in the roles played by federal, state and local governments.

This chapter presents a brief history of floodplain management in the United States since 1900.

1900-1960: THE STRUCTURAL ERA

The "structural era" of floodplain management began with little direct federal involvement in flood control. Direct federal involvement was soon established and by the 1950s there was increasing recognition of the need for a broader management approach that would go beyond the structural measures to "control" floods.

EARLY INVOLVEMENT THROUGH NAVIGATION AND CONSERVATION PROGRAMS

During the 1800s and early 1900s, flood control efforts were undertaken by levee districts, conservancy districts, other local and quasi-public groups and individual landowners. Federal involvement in flood control was sporadic and concerned mainly with the impacts of flooding on navigation, or indirectly concerned with forestry or agricultural programs.[1] For example, beginning in 1824 the Corps of Engineers (Corps) was involved with selected river and harbor improvements. Also, the Act of 1897 relating to forest reserves and the Weeks Act of 1911, which authorized the purchase of new national forest land, were concerned with the amelioration of water flows from timbershed catchment areas, and thus the flooding and flows of navigable rivers and streams (Hoyt, 1955). The Corps had been continuously involved with river and harbor improvements since 1824, but the focus was on navigation, not flood control. After the Civil War, Congress assumed greater responsibility for flood forecasting and warning by authorizing federal agencies such as the Corps and the U.S. Geological Survey (USGS) to initiate stream gaging activities (Corps of Engineers, 1988). Due to public concern about logging practices at the turn of the century, two short-term paired watershed studies were conducted by the U.S. Forest Service (FS) in Colorado (Bates, 1928), and by the U.S. Geological Survey (USGS) in New Hampshire (Leighton, 1913) to study the relationship between timber harvest and water flow. The New Hampshire study responded to the 1911 Weeks Act. Direct federal involvement in flood control, however, remained limited.

DIRECT FEDERAL INVOLVEMENT IN FLOOD CONTROL

The Flood Control Act of 1917 (P.L. 64-367) was enacted following major flooding on the Mississippi River and marks the beginning of direct federal commitment to flood control. Ten years later in 1927, another major Mississippi River flood resulted in the Flood Control Act of 1928 and Corps responsibility for flood control and navigation on the river. Later, after major flood disasters in New England, the Ohio River, and the Potomac and Susquehanna river basins, the Flood Control Act of 1936 (P.L. 74-738) expanded federal responsibility to all navigable rivers of the Nation and authorized over 200 flood control projects in 31 states. The Flood Control Act of 1938 further extended the scope of federal involvement, assigning the full cost of building and maintaining reservoirs and channel improvements and rectification projects to the federal government. (The 1941 Flood Control Act restored local cooperation requirements for channel projects.) The Corps was assigned the major role in these structural flood control efforts (Hoyt, 1955).

Although often overlooked, the early flood control acts did address both structural and nonstructural measures. For example, the 1936 Act recognized that improvement of watersheds for flood control was a proper federal function. It sought to reconcile conflicting views of the role of upstream and watershed measures by simply providing for them without any systematic integration with structural measures (White, 1989). The 1938 Act authorized evacuation of floodable areas in lieu of structural measures, if economically feasible. Clearly though, the federal emphasis was on structural solutions, beginning a long tradition of construction of dams, levees and channel modifications.

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[1] *Floods*, by Hoyt and Langbein, 1955, includes an extensive description of early flood control efforts in the 1700s to 1900s.

> *The magnitude of the effort and the pressing need in the late 1930s and the early 1940s to protect as many rural and urban communities as practical and feasible and as soon as possible, left little time for other considerations. Thus, it was during this early era that the concept of controlling floods with structural measures became widespread, prevalent, and almost 'institutionalized'* (Donovan, 1983).

By 1961 — twenty-five years after the first legislation providing for federal participation in flood control on a nationwide basis — the authorized flood control program of the Corps consisted of over 900 projects with an estimated federal cost of about $9 billion. Projects completed or under construction in 1961 included about 220 reservoirs with nearly 90,000,000 acre-feet of flood control capacity, over 9,000 miles of levees and floodwalls, and some 7,400 miles of channel modifications. Authorized projects not yet started at that time would have added 40,000,000 acre-feet of flood storage capacity in 120 additional reservoirs, almost 3,100 miles of levees and floodwalls, and 3,300 miles of channel modifications (Cassidy, 1962).

Other federal agencies became involved in flood control through a variety of resource conservation and economic development programs. The TVA Act of 1933 established the Tennessee Valley Authority (TVA) and its regional program of resource development, including construction of dams and reservoirs for flood control. From the 1930s to 1950s, the Bureau of Reclamation (BOR) and the U.S. Department of Agriculture (USDA) began including flood control along with other project considerations, and a national program for upstream watersheds was authorized. Also in the period of 1930 to 1950, the Forest Service embarked on major flood control research in the Intermountain Region and the technology developed has been extensively applied in Utah. By 1955, the Soil Conservation Service (SCS) of the USDA was providing assistance for the application of conservation measures (including flood prevention measures) to individual landowners and operators in 2,600 soil conservation districts.

Other early involvement by the federal government in flood control took place along the international boundary with Mexico. In 1933, a U.S.-Mexico Convention was established providing for boundary stabilization and flood control along a section of the Rio Grande River. The U.S.-Mexico Water Treaty of February 3, 1944 provides the basis for international flood control projects along the boundary sections of the Rio Grande and the Colorado River. The federal agency charged with implementing these and other treaty-derived responsibilities for flood control and floodplain management along the international rivers is the U.S. Section, International Boundary and Water Commission, United States and Mexico. Subsequent U.S.-Mexico agreements affecting flood control include the Convention of August 29, 1963 and the Boundary Treaty of November 23, 1970. The latter agreement provides for boundary river stabilization and international management of the boundary river floodplains (International Boundary and Water Commission, 1989).

Along with acceptance of federal involvement in flood control came increasing federal involvement in disaster relief. The Federal Disaster Act of 1950 (P.L. 81-875) was the Nation's first comprehensive disaster relief act, and Small Business Administration (SBA) disaster relief programs were initiated in the 1950s.

FLOOD "CONTROL" VS. FLOOD "MANAGEMENT"

Although the emphasis during the first half of this century was on structural means to "control floods" and on federal financing (with limited state or community cost sharing), the need for a broader approach to flood control and the concept of flood "management" (rather than "control") was being studied and applied. In his 1942 dissertation "Human Adjustments to Floods," Dr. Gilbert White presented a comprehensive theory of a broad, geographic approach to the flood problem involving "...an integration of engineering, geographic, economic, and related techniques." He also noted that "The solutions will not involve a single line of public or private action but will call for a combination of all eight types of adjustments, judiciously selected with a view to the most effective use of floodplains" (White, 1945). The eight types of adjustments that White discussed were: land elevation, flood abatement, flood protection, emergency measures, structural adjustments, land-use readjustments, public relief, and insurance.

In 1950, a Water Resources Policy Commission appointed by President Truman included among its recommendations that federal authorities consider floodplain zoning and flood forecasting as integral parts of flood management. A 1951 report of the Engineers Joint Council ("Principles of a Sound National Water Policy") also addressed land management through emphasis on "sustained land utility" rather than flow retardation. There was also an attempt to establish a federal flood insurance program after the 1951 floods on the Kansas and lower Missouri rivers, but both Congressional reaction and a report sponsored by the Insurance Executives Association were unfavorable. In their 1955 book *Floods*, Hoyt and Langbein discussed current flood control policy: "Even now there are ideas and influences at work within government seeking to foster consideration of flood-plain development and re-development, relocation, zoning of flood plains, flood-forecasting, and storage of water on cultivated fields or underground as supplementary means for effective control of flood damage" (Hoyt, 1955).

The TVA initiated its regional floodplain management assistance program in 1953, providing technical assistance to communities as the basis to encourage floodplain regulations. From 1953 to 1960 the TVA floodplain management program emphasized land-use regulation in floodprone areas, but was later broadened to include consideration of all nonstructural measures, as well as flood control structures. One of the first TVA floodplain management studies was in the twin cities of Bristol, Tennessee-Virginia. A 1956 flood hazard information report recommended the adoption of local floodplain regulations. A local flood study committee, with technical assistance from the state, then developed a comprehensive plan for flood damage prevention. The Bristol approach was applied in several other communities within the TVA region.

The TVA's floodplain management program was described and recommended for national application in the report "A Program for Reducing the National Flood Damage Potential," prepared for the Senate in March 1959 (Tennessee Valley Authority, 1983).

THE 1960s: A TIME OF CHANGE

During the 1960s, there was recognition of increasing flood losses and accelerating disaster relief costs despite the billions of dollars in federal investments in structural projects. As a result, major steps were taken to redefine federal policy and approaches to flood control. A major change in the composition of Congressional representation, initiated following the 1960 census, also had a significant input on federal water policy. Redistricting started the process of replacing rural (largely southern and western) project-oriented Congressmen with urban, grant-oriented members and the realignment of traditional Congressional coalitions (Thomas, 1983).

This realignment of Congressional coalitions affected all water policy. It also had a major impact on the recognition of natural and beneficial resources as reflected in the National Environmental Policy Act of 1969 (P.L. 91-190) and its related preceding and following legislation. At the same time, emphasis began to shift from a river basin to a site development focus (Thomas, 1983b, 1988).

Following the Senate's review of the 1959 TVA report, Section 206 of the Flood Control Act of 1960 (P.L. 86-645) authorized the Corps of Engineers to provide technical services and planning assistance to communities for wise use of the floodplain and for ameliorating the flood hazard. Under this authority, the Corps established a National Floodplain Management Services Program and began producing maps and floodplain information reports (patterned after reports already being prepared by the TVA) describing flood hazard in terms of the area prone to floods, the history of flooding, depths of flooding experienced or expected, velocities of flood flows, and the time characteristics of floods. The studies and assistance were provided largely at federal expense. Local interests were encouraged to provide mapping and other survey information and to use the results in their planning toward wise use of the floodplain (U.S. Army Corps of Engineers, 1968). By the end of fiscal year 1969, over 300 flood plain information reports had been issued (U.S. Army Corps of Engineers, 1970).

The President's water policy statement of 1962[2] established policies and procedures related to comprehensive river basin plans and individual projects. The Water Resources Planning Act of 1965 (P.L. 89-80) created the U.S. Water Resources Council (WRC) and authorized the creation of federal-state river basin commissions. Several river basin commissions were formed and began producing comprehensive basin plans. The first plans produced by the river basin commissions made only general recommendations regarding floodplain management — principally that states and communities use the Corps' floodplain information studies to supplement specific flood control measures and land treatment programs included in the plan. Later studies included more detailed recommendations, including floodplain zoning, preparation of floodplain information studies and programs, and other land-use regulations such as state coastal zone legislation and creation of basin-wide wild and scenic rivers programs (Holmes, 1979).

The growing recognition of the need for alternative approaches to flood loss reduction was also reflected in state government actions. In 1966, for example, Wisconsin's Water Resources Act

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2 Prepared by the Secretaries of the Interior, Agriculture, Army, and Health, Education and Welfare; and published as Senate Document 97, *Policies, Standards, and Procedures in the Formulation, Evaluation, and Review of Plans for Use and Development of Water and Related Land Resources* (Buie, 1979).

mandated local regulation of flood hazard and shoreline areas consistent with state standards and in 1969 Minnesota adopted a state floodplain management program in conjunction with a shoreland zoning program (Kusler, 1982). In 1958, seven states had adopted and were enforcing floodplain management regulations, primarily for narrow channel encroachments. By 1969, 15 states had floodplain management statutes, some of which included regulation of the entire floodplain (Bloomgren, 1982).

Local governments also initiated attempts to deal with flood hazards in a more comprehensive manner. For example, with assistance and support from the TVA, the towns of Maryville and Alcoa in the State of Tennessee undertook joint flood damage reduction planning combined with community redevelopment (U.S. Water Resources Council, 1971).

HOUSE DOCUMENT 465 AND EXECUTIVE ORDER 11296

The most significant step toward a more unified federal policy came in 1966, with the establishment of a Bureau of the Budget Task Force on Federal Flood Control Policy. The Task Force's report — House Document 465, "A Unified National Program for Managing Flood Losses," August 1966 — has been called the "Magna Carta of contemporary floodplain management planning" (Donovan, 1983). Citing numerous problems — mounting flood losses, inadvertent encouragement of floodplain encroachment, increasing damage potential under existing policies, and the inability of current programs to prevent catastrophes, among other problems — the report advocated a broader perspective on flood control within the context of floodplain development and use. H.D. 465 included five major goals:

1) TO IMPROVE BASIC KNOWLEDGE ABOUT FLOOD HAZARD.
2) TO COORDINATE AND PLAN NEW DEVELOPMENTS ON THE FLOODPLAIN.
3) TO PROVIDE TECHNICAL SERVICES TO MANAGERS OF FLOODPLAIN PROPERTY.
4) TO MOVE TOWARD A PRACTICAL NATIONAL PROGRAM FOR FLOOD INSURANCE.
5) TO ADJUST FEDERAL FLOOD CONTROL POLICY TO SOUND CRITERIA AND CHANGING NEEDS.

The report also included recommendations on ways to achieve these ambitious goals. (Subsequent revisions to the Unified National Program are discussed in later sections of the *Assessment Report.*)

Executive Order 11296, Flood Hazard Evaluation, was issued at the same time as the Task Force report and directed federal agencies to evaluate the flood hazard before undertaking federally financed or supported actions and to play a lead role in preventing uneconomic use and development of floodplains. The task of developing the framework, including specific legislative and other programmatic needs to implement the Unified National Program, was assigned to the U.S. Water Resources Council (The President, 1966).

THE NATIONAL FLOOD INSURANCE PROGRAM AND THE NATIONAL ENVIRONMENTAL POLICY ACT

While H.D. 465 and E.O. 11296 provided the groundwork for redirecting the federal involvement from structural control to a more comprehensive approach to management of the floodplain, two major legislative actions were also significant — establishment of the National Flood Insurance Program (NFIP) and passage of the National Environmental Policy Act (NEPA).

At the same time the 1966 Task Force was evaluating flood control policy, the Department of Housing and Urban Development (HUD) was studying the feasibility of a national flood insurance program. The Southeast Hurricane Disaster Relief Act of 1965 (P.L. 89-339), enacted after Hurricane Betsy caused extensive damage, particularly in the Gulf states, had authorized such a feasibility study. HUD's 1966 report provided the basis for the National Flood Insurance Act (NFIA) of 1968 (P.L. 90-448)[3] (Holmes, 1979).

Through the NFIP, relief from the impacts of flood damages in the form of federally subsidized flood insurance became available to participating communities, contingent upon nonstructural flood loss reduction measures embodied in local floodplain management regulations. Community participation in the NFIP was relatively limited until the Flood Disaster Protection Act of 1973 (P.L. 93-234) amended the NFIA to strengthen incentives for local participation. Often overlooked is the importance of the NFIP's 1968 decision establishing the one percent chance flood as a national standard; a decision that Congress concurred with in 1973.

Passage of NEPA in 1969 provided for the consideration of environmental values in federal and federally supported actions. NEPA proved to be a major tool allowing for recognition of the multiple functions of the floodplain and for guiding use and development of floodplain lands. In addition, passage of NEPA signaled the initiation of the "environmental decade" to follow.

THE 1970s: THE ENVIRONMENTAL DECADE

During the 1970s, both the policy framework and management tools for floodplain management changed significantly, as did the national context within which floodplain use and development occurred. At the same time that national policy shifted toward decentralization of water management programs and toward nonstructural solutions to floodplain management, congressional support for major water resource development projects decreased. As a result of Congressional redistricting the number of Congressmen from urban districts steadily increased, while the strength of the rural groups that traditionally supported large water development projects continued to decline (Thomas, 1983). Numerous "environmental" laws and programs at the federal and state levels, as well as specific water policy initiatives, opened the way for a much broader perspective on floodplains and a more comprehensive approach to their management.

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3 The first national flood insurance program was enacted by Congress in 1956, but was never funded.

LAND AND WATER USE PLANNING TOOLS

With the passage of NEPA, the establishment of environmental quality as a national goal, and the requirement for environmental impact statements for proposed federal projects and actions, major activities affecting floodplains and specific flood control projects became subject to greater public scrutiny, and more importantly, consideration of alternatives. Complimentary environmental legislation was adopted by many states, establishing environmental quality review and environmental impact assessment requirements at the state and local levels.

Other land and water use planning tools also affected the decision-making process for floodplain use and facilitated the consideration of alternative strategies for dealing with potential flooding impacts:

- *The Coastal Zone Management Act of 1972* (P.L. 92-583) provided for more direct state attention to coastal resources, including coastal flood hazard areas. Through the coastal management programs, states initiated or refined land and water use control procedures and programs in their coastal flood hazard areas.
- *The Water Pollution Control Act Amendments of 1972* (P.L. 92-500) assigned to the U.S. Environmental Protection Agency (EPA) the responsibility to issue permits to regulate or prohibit pollutant discharges into the Nation's rivers. The Corps was given the responsibility (Section 404) to issue permits for dredge and fill activities in the Nation's waters. The Act also called for intensified planning and intergovernmental coordination in waste treatment facilities (Section 208) and in river basin planning (Section 209).
- *The Disaster Relief Act of 1974* (P.L. 93-288) required the development of state disaster preparedness plans for floods and other natural hazards as a condition of receiving federal disaster assistance.

EXPANDING FRAMEWORK FOR FLOODPLAIN MANAGEMENT

Integration of strategies for floodplain management was further enhanced through several more directly related policy and legislative initiatives, including changes to the NFIP and publication of the "Principles and Standards for Planning of Water and Related Land Resources."

- *The Flood Disaster Protection Act of 1973* (P.L. 93-234) amended the National Flood Insurance Act (NFIA), providing stronger incentives for communities to participate in the flood insurance program by tying future federal financial assistance to states or communities and participation in the NFIP. After Tropical Storm Agnes caused over $2 billion in losses in 1972, Congress strengthened the requirements of the NFIP — requiring that communities in designated flood hazard areas adopt appropriate land-use controls as a condition to receiving federal assistance for insurable structures. Between enactment of the NFIA in 1968 and 1973, approximately 3,000 communities joined the program; after the 1973 amendments, community participation increased to approximately 16,000 by mid-1979.
- *The "Principles and Standards for Planning of Water and Related Land Resources"* (Principles and Standards), a presidential policy statement issued in September 1973, established a framework for improved planning in the use of water and related land resources, based on the objectives of National Economic Development (NED) and Environmental Quality (EQ).

- *The Water Resources Development Act of 1974* (P.L. 93-251) addressed the cost-sharing issues raised in H.D. 465 and required the consideration of nonstructural measures in federal flood control projects.
- *The Disaster Relief Act of 1974* (P.L. 93-288) included requirements for applicants to take actions to mitigate hazards as a condition of receiving disaster assistance and that rebuilding be done in conformance with applicable codes, specifications and standards.

In addition, the "Unified National Program" set forth in H.D. 465 was revised in response to new legislative and executive actions — first in 1976, to integrate flood insurance and floodplain management objectives; and again in 1979 to incorporate executive orders on floodplain management and protection of wetlands. (The latest revision, in 1986, is described later in this chapter.)

- *A Unified National Program for Flood Plain Management* was published by the Water Resources Council in July of 1976. This updated and revised version of H.D. 465 was developed in response to Sec. 1302(c) of the National Flood Insurance Act and to problems cited in a 1975 Government Accounting Office (GAO) report "National Attempts to Reduce Losses from Floods by Planning for and Controlling the Uses of Flood-Prone Lands." The 1976 program noted the existence of new tools for managing natural resources, including floodplain lands, with an emphasis on the need for greater intergovernmental coordination for effective management.
- *Executive Order 11988, Floodplain Management*, and *Executive Order 11990, Protection of Wetlands*, were issued in May, 1977. E.O. 11988, which relies on authority provided in both the NFIA and NEPA, specified the responsibilities of federal agencies in floodplain management. Superseding the 1966 executive order on flood hazard evaluation and reflecting the new context for management of floodplains, it directed federal agencies to evaluate the potential effects of their actions on floodplains (including the consideration of "natural and beneficial values" of floodplains) and to include the evaluation and consideration of flood hazards in agency permitting and licensing procedures. Since federal actions covered by the E.O. include federal financing programs, the requirements apply to a broad range of construction and development activities at state and local levels. The E.O. also established the one percent chance flood as the standard to be used by all federal agencies.
- *Executive Order 12127*, issued on March 31, 1979, created the Federal Emergency Management Agency (FEMA) to coordinate federal hazard mitigation efforts and to consolidate the programs of five related agencies (the Federal Insurance Administration, the Federal Disaster Assistance Administration, the Defense Civil Preparedness Agency, the Federal Preparedness Agency, and the U.S. Fire Administration).
- *A Unified National Program for Floodplain Management* was updated again by Water Resources Council in September, 1979 to incorporate the new federal policy on flood management as set forth in E.O. 11988.
- The *Principles and Standards* were also updated and revised in late 1979. The revisions required that a primarily nonstructural alternative plan be prepared and considered as an alternative whenever structural water resources projects are proposed. The "Principles and Standards" also encouraged specific consideration of the ecological values associated with floodplains as part of the environmental quality evaluation process, further defining the "natural and beneficial values" cited in E.O. 11988.

- In addition, a series of studies to identify and implement opportunities for floodplain management were initiated by the WRC in the 1970s. This effort led directly to the creation of the interagency agreement establishing Interagency Hazard Mitigation Teams and the funding of Section 1362 of the NFIA for purchase of flood-damaged properties (U.S. Water Resources Council, 1979).

INCREASING STATE AND LOCAL INVOLVEMENT IN FLOODPLAIN MANAGEMENT

During the 1970s, more state and local governments became involved in floodplain management through passage of state legislation addressing specific activities, participation in the NFIP, initiation of multi-purpose planning programs, or development of specific "innovative" projects. Regulatory accomplishments at the state and local levels during the decade included (Kusler, 1982):

1) AT THE STATE LEVEL:

    - appointment of state flood insurance program coordinators in all 50 states;
    - adoption of new floodplain regulatory programs by seven more states and strengthening of programs by others;
    - increases in staff and budgets of state programs for mapping, technical assistance, and permit evaluation;
    - growth of state expertise, aided by access to WRC Water Resource Planning Grant funds and subsequent NFIP State Assistance Funds;
    - adoption of resource conservation legislation that incorporated hazard reduction considerations (e.g., wetlands protection, coastal management); and
    - incorporation of floodplain management measures in multi-purpose programs such as urban renewal and open space acquisition programs.

2) AT THE LOCAL LEVEL:

    - adoption of floodplain regulations by close to 17,000 communities as a condition of enrollment in the NFIP; and
    - adoption of local resource management regulations (e.g., wetlands protection, shoreland zoning, etc.).

There were also many instances of states and localities taking the initiative in multipurpose programs or comprehensive floodplain management programs: e.g., county-funded comprehensive floodplain management program in Baltimore County, Maryland; flood reduction and community revitalization in Soldier's Grove, Wisconsin; floodplain evacuation/relocation in Clinchport, Virginia.

The Association of State Floodplain Managers (ASFPM) was founded in 1977, providing a significant forum for the sharing of expertise and experience in state and local floodplain management programs and assistance in improving the effectiveness of those programs.

THE 1980s: CONTINUING EVOLUTION OF FLOODPLAIN MANAGEMENT

Actions in the 1970s resulted in a broad planning framework for floodplain management — through both land-use related legislation and specific water policy initiatives. During the 1980s, the significant "new" legislative or institutional changes were few. Rather, more attention was given to implementing policies and programs. The federal government took on more of a coordinative role, providing direction and technical assistance. State and local governments gradually increased their role in fashioning floodplain management strategies appropriate to their jurisdictions.

Two interagency agreements were developed in 1980 in attempts to improve federal governmental coordination in the provision of programs and services related to flood damage reduction. One interagency agreement — "Use of Nonstructural Measures in Flood Damage Reduction and Floodplain Management" — was intended to establish common policy among the water resource construction agencies on nonstructural flood loss reduction (Thomas, 1983).

A second interagency agreement was developed after a 1980 Office of Management and Budget (OMB) directive that "all Federal programs that provide construction funds and long-term recovery assistance must use common flood disaster planning and postflood disaster recovery procedures" (Office of Management and Budget, 1980). The purpose of the directive was to utilize the leverage of the immediate postflood situation to encourage nonstructural flood loss reduction and to link the efforts of disaster recovery agencies and agencies involved in planning and construction.

As a result, 12 federal departments and agencies signed an interagency agreement committing them to a common policy and procedures, implemented through the action of interagency hazard mitigation teams (IHMT). These teams, activated after Presidentially declared disasters and under FEMA's leadership, provided another vehicle for evaluating a range of floodplain management opportunities, particularly those that might arise out of the postdisaster context (e.g., relocation of damaged structures). The teams make recommendations to all levels of government concerning a mix of strategies and tools that might be used to mitigate against future flood losses. The teams do not have authority to obligate federal agencies to commit funds or pursue a particular course of action.

The 1980 OMB directive was at least partially in response to activities following a 1978 flood of the Kickapoo River in Wisconsin that devastated portions of the Village of Soldiers Grove. After the flood, the Village assembled funds from several federal, state and local sources and relocated its main business district to a new location out of the floodplain. As a result of this relocation, a partially constructed flood control dam on the Kickapoo River above the Village was never completed. This event generated great interest in the possibilities of postdisaster nonstructural measures. In addition, the confusion created in the federal government by a flooded community shopping for discretionary funds among various agencies stimulated discussions to find a mechanism to coordinate such activities. It was recognized that: a) nonstructural measures, when implemented following floods to take advantage of opportunities presented in the postflood period, could be much more cost-effective and timely than structural measures, and b) the nonstructural approach would require a federal interagency mechanism to coordinate available resources to maximize their effectiveness. This OMB memo and subsequent interagency agreement provided further impetus to the transition from an emphasis on flood control through structural measures to an emphasis on nonstructural floodplain management measures (Zensinger, 1988).

State hazard mitigation planning pursuant to Section 406[4] of the Disaster Relief Act of 1974 was initiated in 1980, following publication of regulations to implement this section of the 1974 law in late 1979. While many state and local communities had been involved in hazard mitigation previously, Section 406 planning requirements made evaluation of mitigation opportunities mandatory after a presidential declaration of disaster. The 406 requirements tied the receipt of federal grants or loans for disaster assistance to a state's evaluation of natural hazards and identification of appropriate actions, including safe land-use and construction practices, to mitigate such hazards.

Both the IHMT process (limited to flood disasters and intended primarily to coordinate federal response and recovery) and the 406 planning process (for all types of presidentially declared disasters) provided impetus to greater involvement by state and local officials in hazard mitigation activities as a result of their participation on the teams.

The Coastal Barrier Resources Act of 1982 (P.L. 97-348) prohibits new federal expenditures (including the denial of federal flood insurance and disaster assistance) on undeveloped coastal barriers on the Atlantic and Gulf coasts. The Act incorporates and, in fact, mandates the approach of avoiding high hazard areas, further defining the message that was spelled out in E.O. 11988. The Act defined and identified undeveloped coastal barriers, and placed a general prohibition on all federal activities that might assist development of those barriers. Federal expenditures not prohibited by the Act include Internal Revenue Service (IRS) deductions for casualty losses and federally insured conventional loans.

In 1983, FEMA began to implement the concept of integrated emergency management to encourage state and local progress in responding to all hazards through the Integrated Emergency Management System (IEMS). The IEMS systematic approach to emergency management planning incorporates hazard identification, assessment of state and local capability to deal with hazards, and multi-year planning to improve capability in preparedness, response, recovery and mitigation.

In 1986, *A Unified National Program for Floodplain Management* was updated[5] to reflect changes in federal programs and the strengthening of floodplain management capability at the state and local levels. The 1986 document notes "that the relative role of the Federal government in national floodplain management is declining as local, but especially State, governments have begun to develop experience and effective programs." The report focuses on "ineffective coordination as a major weakness in the use of the limited resources presently devoted to floodplain management", but also recognizes the increasing fiscal burden placed on the states. "Realistically, State legislatures will find it necessary to accept more responsibility to provide levels of funding needed to carry out a compre-

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4 Section 406 was renumbered as Section 409 by the Disaster Relief and Emergency Assistance Amendments of 1988 (P.L. 100-707).

5 Responsibility for leadership of the UNP had been transferred to FEMA in 1982 following zero-level funding of the WRC and transfer of WRC staff to other federal agencies.

hensive State floodplain management program, especially as Federal financial assistance is limited in accord with current Federal deficit reduction policies" (Federal Interagency Floodplain Management Task Force, 1986).

As an indication of the growing state and local role in floodplain management, 27 states had floodplain management statutes in place by 1982 (Bloomgren, 1982). In 1988, 36 states had statutes that either mandated or allowed regulation of riverine and/or coastal floodplains (Association of State Floodplain Managers, 1989). At the end of 1988, about 17,800 communities were participating in the NFIP. On their own initiative or due to state requirements, many of these communities had enacted regulations that exceeded in some instances the minimum floodplain management requirements of the NFIP. States and communities have also actively pursued reduction of flood losses through means other than regulation, including flood preparedness and warning, acquisition of floodprone areas and floodproofing. State and local governments have also been involved in protecting floodplain natural resources, though efforts vary widely across the country and are not always coordinated with loss reduction measures.

Throughout the 1980s, organizations such as the Association of State Floodplain Managers, the Association of State Dam Safety Officials, the Association of State Wetland Managers and the National Association of Urban Flood Management Agencies (now the National Association of Flood and Stormwater Management Agencies) played an increasingly important role in shaping national floodplain management policy and influenced both legislation and budgets.

SUMMARY AND CONCLUSIONS

The history of floodplain management in the United States has been influenced by broad national trends and attitudes with respect to urban growth and development, government spending, expanding technology, recognition of the complexity and interrelationship of issues related to land and water use, and shifting roles among different levels of government. Three major trends have had a particularly important impact on the present status of floodplain management.

The first trend is the integration of the different government programs that affect floodplains. The current status of floodplain management stems from the evolution of programs for water resource projects, disaster assistance and environmental quality. The second trend — the Nation's growing urbanization — has been reflected in Congressional attitudes and representation, resulting in less focus on major flood control and other water resource projects and greater focus on risk management, environmental improvement, ecosystems protection and urban water quality. The third major trend — decentralization of the federal role — has resulted in the development of technical expertise and a greater sharing of the responsibility for floodplain management among federal, state and local governments.

Although floodplain management has matured considerably since the early efforts focused solely on flood control, today's management programs are still evolving in accordance with national trends and efforts to improve and expand the tools for reducing flood losses and protecting natural resources. Additional change can be expected in the future.

CHAPTER 5:

A UNIFIED NATIONAL PROGRAM FOR FLOODPLAIN MANAGEMENT

... [A] unified national program only can be achieved through a partnership among all levels of government wherein each carries out its responsibilities ...

Jeffrey S. Bragg, Former Administrator, Federal Insurance Administration

House Document 465, *A Unified National Program for Managing Flood Losses*, established the foundation of a coordinated national effort to manage the nation's floodplains. In response to a directive in the 1968 National Flood Insurance Act (NFIA), a conceptual framework for a unified national program was set forth in 1976 in *A Unified National Program for Flood Plain Management* (U.S. Water Resources Council, 1976). This document was revised and updated in 1979 (U.S. Water Resources Council, 1979), and again in 1986 (Federal Emergency Management Agency, 1986) to reflect changes in relevant policies, legislation and institutional arrangements, as well as progress in approaches to floodplain management.

The resulting document provides the conceptual framework for floodplain management in the United States today. Because of that document's importance, this chapter presents a relatively detailed account of how *A Unified National Program for Floodplain Management* has evolved over the last 25 years and what the program now encompasses. Figure 5-1 summarizes the evolution of the Unified National Program for Floodplain Management from 1966 to 1986.

HOUSE DOCUMENT 465: A UNIFIED NATIONAL PROGRAM FOR MANAGING FLOOD LOSSES

In August 1966, *A Unified National Program for Managing Flood Losses* was submitted by President Lyndon Johnson to Congress. This document — House Document 465 — had been prepared by the Task Force on Flood Control Policy, at the administration's request, in an attempt to check the mounting national toll of flood losses. In his transmittal letter, the President noted the extent of the Nation's investment in flood control projects (over $7 billion since 1936) and the need to continue support of these traditional programs, but he also recognized the need for new policies and measures to reduce growing annual flood losses and to promote sound development of floodplains.

DATE	DOCUMENT	AGENCY	ACTION
August 1966	A Unified National Program for	Task Force on Federal Flood Control Policy Managing Flood Losses	Prepared at the administration's request and submitted to Congress by the President.
July 1976	A Unified National Program for Floodplain Management	U.S. Water Resources Council	Prepared by WRC in response to Sec. 1302(c) of the NFIA. Submitted to the President, but not transmitted to Congress.
September 1979	A Unified National Program for Floodplain Management	U.S. Water Resources Council	Prepared by WRC to incorporate new policy directions (E.O. 11988 etc.). Submitted to the President and transmitted to Congress.
March 1886	A Unified National Program for Floodplain Management	FEMA (Interagency Floodplain Management Task Force	Prepared by the Interagency Task Force to reflect legislative and other changes. Submitted to the President and transmitted to Congress.

Source: Thomas, Frank. Chairman of the Federal Interagency Floodplain Management Task Force. Personal Communication. 1988.

Figure 5-1. Evolution of a Unified National Program for Floodplain Management.

GOVERNMENTAL RESPONSIBILITIES

The Unified National Program recommended in H.D. 465 emphasized reorientation and strengthening of federal agency programs under existing authorities. Although no new agencies were recommended, some of the task force proposals did call for new legislation, as well as specific studies or research to improve planning capabilities. Responsibility for most of the specific recommendations was assigned to one or more federal agencies. The U.S. Water Resources Council[1] (WRC), which had recently begun operations under authority granted in the Water Resources Planning Act of 1965, was assigned primary responsibility for many aspects of the national program.

[1] See Chapter 7 for a description of the organization and functioning of the Water Resources Council relevant to floodplain management.

Although directed principally at federal agency actions to improve flood management, H.D. 465 did recognize the need for involvement and cooperation among all levels of government as well as private citizens. The Task Force recommended the following division of responsibility (Task Force on Federal Flood Control Policy, 1966):

Federal Responsibilities

- collection and dissemination of data -
- provision of technical services -
- construction of flood control projects -
- management or supervision of indemnification program -
- provision of credit for local contributions to flood projects -

State Responsibilities

- establishing floodplain encroachment lines -
- granting of authority for demarcation of flood hazard areas -
- assisting local planning and project financing efforts -

Local Responsibilities

- guiding desirable expansion and avoiding uneconomic use of high hazard areas -
- organizing flood project beneficiaries to pay for services -

Individual Responsibilities

- weighing of the costs and advantages of developing alternative sites -
- assumption of financial responsibility for new locational decisions -

FLOODPLAIN MANAGEMENT RECOMMENDATIONS

The Task Force also included 16 recommendations for specific action in House Document 465 (these are summarized on Figure 5-2). One recommendation was fulfilled almost immediately when, at the same time that the President transmitted the Task Force report to Congress, he issued Executive Order 11296, Flood Hazard Evaluation, directing federal agencies to evaluate flood hazards prior to funding new construction or the purchase or disposal of lands. In his transmittal letter, however, the President named the Bureau of the Budget — rather than the new Water Resources Council as recommended by the Task Force — to be the agency through which interested federal agencies would report action. This reportedly led to long delays in achieving agency action (White, 1989).

Each edition of *A Unified National Program for Floodplain Management* has included a status report on the progress achieved in implementing the recommendations made in H.D. 465. Progress is categorized as: "(A) largely implemented; (B) some progress (often legislated but not implemented); and (C) little or nothing accomplished." Figure 5-2 indicates the status of implementation progress as determined by the Federal Interagency Floodplain Management Task Force (and its predecessors) in 1976, 1979, and 1986. Of the 16 specific actions that were recommended, seven were judged to have been largely implemented by 1986, some progress was seen with regard to the implementation of eight other recommendations, and only one recommendation (a new national program for collecting more useful flood damage data) was judged as "little or nothing accomplished."

A UNIFIED NATIONAL PROGRAM FOR FLOOD PLAIN MANAGEMENT, 1976

Ten years after H.D. 465 focused attention on the need for a new approach to managing flood losses, the WRC submitted *A Unified National Program for Flood Plain Management* to the President.[2] H.D. 465 provided the foundation for a national flood management program, recognized the need for a unified approach and for new planning measures, and made numerous recommendations for specific actions. It did not, however, provide a detailed framework within which federal, state and local agencies could formulate effective policies and implement floodplain management activities.

Section 1302 (c) of the National Flood Insurance Act (NFIA) of 1968 (P.L. 90-448) had directed that:

> *The objectives of a flood insurance program should be integrally related to a unified national program for floodplain management and ... the President should transmit to Congress for its consideration any further proposals necessary for such a unified program, including proposals for the allocation of costs among beneficiaries of flood protection.*

In 1968, the Bureau of the Budget[3] requested that the WRC prepare a report in response to the directive contained in Section 1302 (c) of the NFIA. In addition, the shortcomings of H.D. 465 and E.O. 11296 were cited in a March 1975 General Accounting Office report (U.S. General Accounting Office, 1975). The report subsequently prepared by the WRC — *A Unified National Program for Flood Plain Management* — was submitted to the President in 1976 and also reflected several pieces of federal legislation passed since 1966 as well as new directives in federal policy that had significantly changed the context for floodplain management. The major changes reflected in the report were:

- Federally subsidized flood insurance had been made available with passage of the National Flood Insurance Act of 1968 (P.L. 90-448).
- Funds for flood disaster preparedness planning were authorized by the Disaster Relief Act of 1974 (P.L. 93-288).
- Technical assistance and construction grants for area-wide waste treatment facility planning were made available under the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500).

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2 The 1976 report and subsequent 1979 and 1986 revisions were submitted to the President for transmission to Congress. The 1979 and 1986 reports were transmitted to Congress while the 1976 report was not.

3 Predecessor agency to the Office of Management and Budget.

SUMMARY OF H.D. 465 RECOMMENDATIONS		IMPLEMENTATION PROGRESS*		
		1976	1979	1986
A. To improve basic knowledge about flood hazard:				
1. A three-stage program of delimiting hazards should be initiated by the Corps of Engineers, the Geological Survey, and other competent agencies.		B	B	A
2. A uniform technique of determining flood frequency should be developed by a panel of the Water Resources Council.		A	A	A
3. A new national program for collecting more useful flood damage data should be launched by the interested agencies, including a continuing record and appraisals in census years.		C	C	C
4. Research on (1) floodplain occupancy and (2) urban hydrology should be sponsored by the Department of Housing and Urban Development, the Department of Agriculture, and the Geological Survey.	(1) (2)	C B	C B	B B
B. To coordinate and plan new developments on the floodplain:				
5. The Federal Water Resources Council should specify criteria for using flood information and should encourage States to deal with coordination of floodplain planning, and with floodplain regulation.		B	B	B
6. Under the following Federal programs, steps should be taken to assure that State and local planning takes proper and consistent account of flood hazard: Federal mortgage insurance Comprehensive local planning assistance Urban transport planning Recreation open space and development planning Urban open space acquisition Urban renewal Sewer and water facilities (Many of the necessary coordinating actions were accomplished during final preparation of H.D. 465.)		B	B	B
7. Action should be taken by the Office of Emergency Planning, the Small Business Administration, and other agencies to support consideration of relocation and floodproofing as alternatives to repetitive reconstruction.		B	B	B
8. An Executive Order should be issued directing Federal agencies to consider flood hazard in locating new Federal installations and in disposing of Federal land.		A	A	A
C. To provide technical services to managers of floodplain property:				
9. Programs to collect, prepare, and disseminate information and to provide limited assistance and advice on alternate methods of reducing flood losses, including floodplain regulation and floodproofing, should be undertaken by the Corps of Engineers in close coordination with the Department of Agriculture.		A	A	A
10. An improved national system for flood forecasting should be developed by the Environmental Science Services Administration as part of a disaster warning system.		B	B	B
D. To move toward a practical national program for flood insurance:				
11. A five-stage study of the feasibility of insurance under various conditions should be carried forward by the Department of Housing and Urban Development.		A	A	A
E. To adjust Federal flood control policy to sound criteria and changing needs:				
12. Survey authorization procedure and instructions should be broadened in concept.		A	A	A
13. Cost-sharing requirements for federally assisted projects should be modified to provide more suitable contributions by State and local groups.		B	B	B
14. Flood project benefits should be reported in the future so as to distinguish protection of existing improvements from development of new property.		A	A	A
15. Authority should be given by the Congress to include land acquisition as part of flood control plans.		B	B	B
16. Loan authority for local contributions to flood control projects should be broadened by the Congress.		C	C	B

* From status reports in A Unified National Program for Floodplain Management: **A** = Largely Implemented; **B** = Some Progress (often legislated, but not implemented); **C** = Little or nothing accomplished

Sources: U.S. Water Resources Council. A Unified National Program for Flood Plain Management. Washington, D.C.: U.S. Water Resources Council, 1976 and 1979; Federal Interagency Floodplain Management Task Force. A Unified National Program for Floodplain Management. Washington, D.C.: Federal Emergency Management Agency, 1986.

Figure 5-2. House Document 465 Recommendations for Federal Agency Action.

- States were granted financial assistance for development of coastal management programs under the Coastal Zone Management Act (P.L. 92-583).
- Requirements for dredge and fill permits (Section 404) expanded federal jurisdiction over development in wetlands (P.L. 92-500).
- Cost sharing was extended, in principle, to nonstructural flood control measures under the 1974 Water Resources Development Act (P.L. 93-251).
- Publication of the "Principles and Standards for Planning of Water and Related Land Resources" by the U.S. Water Resources Council in 1973 revised the procedures for evaluation of federally funded management efforts.
- Consideration of alternatives affecting floodplain management was required in environmental impact statements prepared in response to the National Environmental Policy Act (P.L. 91-190).

The 1976 report also addressed the following more serious problems to be overcome in implementing a Unified National Program:

- Fragmented and uncoordinated responsibility for floodplain management.
- Over-reliance on public investment to solve problems.
- Inability to resolve conflicts of private property rights with state and national interests.

REFINEMENT AND EXPANSION OF HOUSE DOCUMENT 465

The 1976 report *A Unified National Program for Flood Plain Management* expanded on the ideas embodied in H.D. 465 in several important ways. It provided a conceptual framework of general and working principles and set forth management "strategies" and implementing "tools" to guide federal, state and local decision-makers in implementing a national program for floodplain management. In addition, the 1976 report included more specific recommendations for federal and state actions to reduce flood losses through floodplain management, and expanded on the role of federal, state and local governments in implementing a Unified National Program.

The report was accompanied by recommendations for a revised, updated version of Executive Order 11296, Flood Hazard Evaluation, to reflect the above-noted legislation passed since 1966 and to implement the expanded Unified National Program at the federal level. Although not adopted by the President, the recommendations became the stimulus for E.O. 11988, Floodplain Management, adopted in 1979.

While H.D. 465 emphasized reorientation and strengthening of existing programs, the 1976 Unified National Program focused on the need for improved coordination, which was cited as the "weakest component of current management efforts."

CONCEPTUAL FRAMEWORK, STRATEGIES AND TOOLS FOR FLOODPLAIN MANAGEMENT

As noted previously, a major problem in implementing a unified national approach to reduce flood losses was the lack of a specific framework for decision-making. The 1976 report presented a conceptual framework within which floodplain management policy could be formulated, along with a set of "strategies" and "tools" to guide decision-making for specific floodplain management activities.

The conceptual framework consisted of general principles and working principles. General principles set forth in the 1976 report *A Unified National Program for Flood Plain Management* are concerned with governmental responsibility for managing floodplains, the context within which the floodplain and flood loss reduction should be viewed, and the components of sound floodplain management.

General Principles

In summary, the general principles for floodplain management as set forth in the 1976 report *A Unified National Program for Flood Plain Management* are:

- The federal government has a fundamental interest in how the Nation's floodplains are managed, but the basic responsibility for regulating floodplains lies with the state and local governments.
- The floodplain must be considered in the context of total community, regional and national planning and management.
- Flood loss reduction should be viewed in the larger context of floodplain management, rather than as an objective in itself.
- Sound floodplain management embodies several aspects:
    - Goals (wise use, conservation, development and utilization of resources) and objectives (economic efficiency, environmental quality and social well-being);
    - Consideration of future needs and the role of the floodplain;
    - Evaluation of all alternative strategies for alleviating flood losses;
    - Accounting for benefits and costs and interrelated impacts of floodplain management actions;
    - Motivation of decision-making individuals;
    - Coordination of agencies at all government levels and with responsibilities for all aspects of floodplain management (regulation, planning functional areas such as water quality and water supply, disaster preparedness and response, and citizen participation); and
    - Evaluation through continuous monitoring and reporting to the public.

Working Principles

The working principles set forth include definitions (of floodplains, flood hazard, flood evaluation, serious flood conditions, and flood disaster assistance), as well as a series of general statements regarding the nature of flooding and floodplain management that provide further guidance for the development of floodplain management policies (for example, existing and new development should be treated differently in floodplain management, flood characteristics are likely to change as development and land-use changes take place, and costs of floodplain management programs ought to be shared equitably among the beneficiaries).

Strategies and Tools

Three approaches or "strategies" for achieving flood loss reduction objectives were also set forth in the 1976 *A Unified National Program for Flood Plain Management*:

1) Modify susceptibility to flood damage and disruption: actions to avoid dangerous, uneconomic, undesirable, or unwise use of the floodplain.

2) Modify flooding: the traditional strategy involving construction of dams, dikes, levees and floodwalls; channel alterations; high flow diversions and spillways; and land treatment measures.

3) Modify the impact of flooding on individuals and the community: actions designed to assist the individual and the community in the preparatory, survival and recovery phases of floods.

A number of specific "tools" associated with each of these basic strategies were described. The strategies and tools are summarized on Figure 5-3.[4] The use of flood loss reduction strategies and tools are discussed in Chapters 11-13.

NEW FLOODPLAIN MANAGEMENT RECOMMENDATIONS

The 1976 Unified National Program made several specific recommendations "directed toward recognition and acceptance of the conceptual framework" and to provide the institutional coordination necessary for implementing a unified national program for floodplain management. These included federal, state and federal-interstate recommendations[5] (U.S. Water Resources Council, 1976).

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[4] The listing of strategies and tools in Figure 5-3 is taken from the 1986 (most recent) edition of *A Unified National Program for Floodplain Management*, and includes a few changes from the original 1976 edition.

[5] Although the directive contained in Section 1302 of the NFIA included a request for proposals for cost-sharing, these recommendations were excluded from the Unified National Program since they were addressed in a separate report being prepared in response to the Water Resources Development Act of 1974.

STRATEGIES AND TOOLS FOR FLOOD LOSS REDUCTION

STRATEGY A: MODIFY SUSCEPTIBILITY TO FLOOD DAMAGE AND DISRUPTION

1. FLOODPLAIN REGULATIONS
   - a) State Regulations for Flood Hazard Areas
   - b) Local Regulations for Flood Hazard Areas
     - 1) Zoning
     - 2) Subdivision Regulations
     - 3) Building Codes
     - 4) Housing Codes
     - 5) Sanitary and Well Codes
     - 6) Other Regulatory Tools
2. DEVELOPMENT AND REDEVELOPMENT POLICIES
   - a) Design and Location of Services and Utilities
   - b) Land Rights, Acquisition and Open Space Use
   - c) Redevelopment
   - d) Permanent Evacuation
3. DISASTER PREPAREDNESS
4. DISASTER ASSISTANCE
5. FLOODPROOFING
6. FLOOD FORECASTING AND WARNING SYSTEMS AND EMERGENCY PLANS

STRATEGY B: MODIFY FLOODING

1. DAMS AND RESERVOIRS
2. DIKES, LEVEES AND FLOODWALLS
3. CHANNEL ALTERATIONS
4. HIGH FLOW DIVERSIONS
5. LAND TREATMENT MEASURES
6. ON-SITE DETENTION MEASURES

STRATEGY C: MODIFY THE IMPACT OF FLOODING ON INDIVIDUALS AND THE COMMUNITY

1. INFORMATION AND EDUCATION
2. FLOOD INSURANCE
3. TAX ADJUSTMENTS
4. FLOOD EMERGENCY MEASURES
5. POST FLOOD RECOVERY

Source: Federal Interagency Floodplain Management Task Force. A Unified National Program for Floodplain Management. Washington, D.C.: Federal Emergency Management Agency, 1986.

Figure 5-3. Strategies and Tools for Flood Loss Reduction.

Federal Level Recommendations

- coordination at the national level for research, data collection and information dissemination -
- strengthening of management tools -
- support of state programs -

State Level Recommendations

- adoption of state enabling legislation, where needed -
- designation of state agencies for floodplain management responsibility -
- development of an information program to supplement federal efforts -
- improvement of management tools -
- support of regional, sub-state and local floodplain management activities -

Federal-Interstate Compact Commission Recommendations

- coordination and support of federal and state floodplain management programs -

1979 REVISIONS TO A UNIFIED NATIONAL PROGRAM FOR FLOODPLAIN MANAGEMENT

While the 1976 report *A Unified National Program for Flood Plain Management* significantly advanced floodplain management by establishing a decision-making framework, the report was quickly dated by several executive level actions, specifically: floodplain management policy articulated in President Carter's 1977 Environmental Message; executive orders on Floodplain Management (E.O. 11988) and Wetlands Protection (E.O. 11990); and the President's June 1978 Water Policy Initiatives. The Federal Interagency Floodplain Management Task Force updated and refined the 1976 Unified National Program in a report submitted to the President in September 1979 by the WRC (U.S. Water Resources Council, 1979).

In addition to the three major problems hindering effective floodplain management that were noted in the 1976 report, the revised version added "insufficient awareness of alternative strategies due to lack of adequate technical and procedural information to guide floodplain decision-makers."

Major areas of change to the Unified National Program were concerned with incorporation of "natural and beneficial values" of floodplains to respond to the new policy directives mentioned above, and included:

- Refinement of the conceptual framework (for example: to address preservation and restoration of natural floodplain resources as well as flood loss reduction; to emphasize the shared decision-making responsibility for floodplain management; and to expand the discussion of managing flood losses and alleviation of loss of natural and beneficial resources);

- Addition of definitions (revision of the definitions of "flood or flooding" and flood hazard; and addition of definitions of floodplain resources, floodplain restoration and floodplain preservation);

- Expansion of the working principles regarding floodplain use, flood loss reduction and natural floodplain resources;
- Expansion of strategies and tools to include those for managing natural floodplain resources; and
- Discussion of the federal concern for natural floodplain resources.

STRATEGIES AND TOOLS FOR MANAGING FLOODPLAIN NATURAL RESOURCES

The 1979 report *A Unified National Program for Floodplain Management* identified two basic strategies for managing floodplain natural resources:

1) RESTORATION: proposed actions to provide re-establishment of a setting or environment in which these natural functions can again operate.

2) PRESERVATION: prevention of alteration to the natural and beneficial functions of floodplains or maintenance of the floodplain environment as close to its natural state as possible using all practicable means.

The 1979 report notes that the best means of preserving and protecting remaining natural values is to avoid development within floodplains. However, where avoidance is not practical, several tools (floodplain regulations, development and redevelopment policies, information and education, tax adjustments, and administrative measures) are available to minimize environmental harm and may be integrated with flood loss reduction tools (U.S. Water Resources Council, 1979). The use of strategies and tools for managing floodplain natural resources is described in Chapter 14.

1986 REVISIONS TO A UNIFIED NATIONAL PROGRAM FOR FLOODPLAIN MANAGEMENT

In 1982, the Office of Management and Budget (OMB) assigned responsibility for the Unified National Program to the Federal Emergency Management Agency (FEMA) which assumed chairmanship of the Federal Interagency Floodplain Management Task Force. The Interagency Task Force submitted an updated Unified National Program to the President in March 1986, noting that "the 1979 report [had become] dated by the relative success and changes in federal programs and by strengthening of floodplain management capability at the state and local levels."

The 1986 report reflected changes in federal legislation relevant to floodplain management as well as the results of several major accomplishments realized since completion of the 1979 report, including:

- Use of Federal Flood Hazard Mitigation Teams, established pursuant to a July 1980 OMB memorandum and a subsequent interagency agreement ("Interagency Agreement for

Nonstructural Damage Reduction Measures as Applied to Common Flood Disaster Planning and Post Flood Recovery Practices," December 15, 1980) signed by 12 federal agencies.

- Passage of the 1982 Coastal Barrier Resources Act (P.L. 97-348), which restricted federal expenditures that might encourage development of coastal barriers along the Atlantic and Gulf Coasts.

- Completion of two major studies by the National Science Foundation on *Flood Hazard Mitigation* (1980) and *Developing Flood Hazard Mitigation Priorities* (1982).

Reflecting the increasing capability of state and local floodplain management roles, the report included more explicit recommendations regarding the federal role in supporting state and local initiatives. A total of 11 recommendations were addressed to federal agencies, seen directed at state governments, and four directed at local governments. These recommendations are summarized on Figure 5-4.

SUMMARY AND CONCLUSIONS

The Unified National Program for Floodplain Management has been periodically revised and updated to reflect recognition of new concern and new initiatives taken by each level of government. Each revision of the Unified National Program assessed the progress that had been made in implementing the original 16 recommendations of the 1966 Task Force on Flood Control Policy. By 1986, only one recommendation — a new national program for collecting more useful flood damage data — was assessed as having little or nothing accomplished with regard to its implementation. Despite this record of accomplishment, much remains to be done. Programs for floodplain management must continually be improved and modified to respond to changing times and needs.

The current Unified National Program provides a conceptual framework of general and working principles and sets forth management "strategies" and "tools" for implementing the national program. A major change to the Unified national Program that occurred in 1979 was refinement of the conceptual framework to address protection of natural floodplain resources as well as flood loss reduction and expansion of the strategies and tools to include those for managing natural values. The Unified National Program has served as a device to stimulate and support improvement of floodplain management at all government levels. As an evolving document, further changes are anticipated to accommodate new developments influencing floodplain management.

FEDERAL LEVEL RECOMMENDATIONS

1. Assure that all Federal programs for water, land, and related resources support and implement the precepts of Executive Order 11988; Floodplain Management and of "A Unified National Program for Floodplain Management", as enunciated in this report. RESPONSIBILITY — All Federal agencies.

2. Improved Federal support of States as they exercise their primary role in floodplain management. RESPONSIBILITY - All Federal agencies.

3. Centralize floodplain data sources at the State level. RESPONSIBILITY — The Federal Insurance Administration and Geological Survey should take the lead.

4. Improve Federal support of local government's role in floodplain management. RESPONSIBILITY — All Federal agencies.

5. Accelerate floodplain and hazard studies and improve dissemination of information to States and local users.

6. Support cost sharing policies and project evaluation procedures that facilitate achievement of a desirable mix of structural and nonstructural approaches to flood hazard adjustment. RESPONSIBILITY — All Federal agencies.

7. Require appropriate non-Federal segments of floodplain management programs, including regulations or control measures and local stormwater management plans as a prerequisite to Federal expenditures for the modification of flooding or of the impacts of flooding. RESPONSIBILITY — All Federal agencies.

8. Continue to evaluate the nature, size and trend of the Federal subsidy to the National Flood Insurance Program and develop policies and procedures to decrease or eliminate the subsidy in high hazard areas after the repetitive losses have been experienced. RESPONSIBILITY — Federal Insurance Administration.

9. Improve flood and flash flood forecasting and warning systems to include — but not be limited to — real-time data collection, forecast preparation and dissemination, and public education in the use of system outputs. RESPONSIBILITY — The National Oceanic and Atmospheric Administration and the Federal Emergency Management Agency.

10. Utilize the Federal Interagency Floodplain Management Task Force under the auspices of the Federal Insurance Administration.

11. Utilize the Federal Interagency Post-Flood Hazard Mitigation Task Force, under the auspices of Federal Emergency Management Agency's State and Local Programs Directorate.

STATE LEVEL RECOMMENDATIONS

1. Enact enabling legislation specifically addressing floodplain management programs and regulations in those States where such legislation does not exist or is inadequate for the purpose.

2. Establish or designate a single State agency (or another effective mechanism of coordination) to assure responsibility for floodplain management and to issue State standards as floodplain management guides for State agencies and local entities.

3. Develop an information program to supplement Federal efforts to inform public and local decision makers about flood hazards and floodplain management.

4. Improve management tools by applying the concepts of Federal Executive Order 11988, Floodplain Management to all State agencies and programs.

5. Establish a hazard mitigation team mechanism for State agencies similar to the Federal hazard mitigation team for the purpose of improving the effectiveness of pre- and postflood disaster mitigation planning.

6. Establish a mechanism to identify and monitor unsafe dams and levees and to provide hazard information to communities subject to potential flooding from failure of unsafe dams and levees.

7. Support regional, substate, and local entities in implementing their floodplain management activities.

LOCAL LEVEL RECOMMENDATIONS

1. Designate a single point of contact with lead responsibility to coordinate floodplain management activities and provide liaison with State and Federal floodplain management programs.

2. Adopt and enforce floodplain management measures including zoning subdivision and building codes that at a minimum meet standards recommended by national and State code organizations.

3. Coordinate with adjacent communities to assure that floodplain management practices do not shift the floodplain hazard to adjacent communities.

4. Develop review procedures to periodically assess the effectiveness of the local floodplain management programs.

Source: Federal Interagency Floodplain Management Task Force. A Unified National Program for Floodplain Management. Washington, D.C.: Federal Emergency Management Agency, 1986.

Figure 5-4. Recommendations for Recognition, Acceptance and Implementation of the Conceptual Framework of the *Unified National Program for Floodplain Management.*

PART III:

CHANGES IN FLOODPLAIN MANAGEMENT SINCE THE 1960s

Much has changed in the field of floodplain management since the 1960s when the concept of a unified national program was first established. There have been important technological developments, for example, along with changes in the institutional framework for floodplain management that have resulted in an expanded legislative base, creation of new agencies, and supportive court decisions. In addition, understanding of basic floodplain management concepts has improved, new analytical procedures have been developed, and the institutional and individual perception and awareness of flood hazards and floodplain natural resources have increased.

As a result, many new programs and initiatives have been developed at all levels of government. Many of these programs, however, tend to be single purpose programs that are not always well coordinated with one another. In addition, we have seen a shift away from federal dominance towards a more equal partnership among federal, state and local governments for floodplain management.

Part III of the *Assessment Report* contains five chapters that describe many of the important changes in floodplain management over the past 25 years.

CHAPTER 6:

THE KNOWLEDGE AND INFORMATION BASE

It is evident ... that the nation lacks a comprehensive base of information about many parameters of floods, flood plain use, and the consequences of floods.

A Plan for Research on Floods and their Mitigation in the United States, 1983

Effective floodplain management requires a sound understanding of the physical, biological, and chemical processes that impact on flood hazards and the natural and beneficial resources of floodplains. Perhaps equally important is an understanding of the social processes involved in human interaction with flood hazards and floodplain natural functions. In addition to understanding the processes involved, it is necessary to measure and inventory over time the extent and quality of important floodplain resources and the occurrence and impacts of flood events in order to identify trends and determine the effectiveness of management efforts.

A detailed description of the current "state-of-the-art" for scientific examination of the various natural processes associated with flood hazards and floodplain resources is outside the scope of the *Assessment Report*. Instead, this chapter provides a summary review of efforts to measure and inventory flood hazards and floodplain resources rather than a review of efforts to evaluate the physical, chemical, and biological processes associated with flooding. ("Social" aspects of floodplain management efforts to reduce losses and protect natural values are addressed in Chapter 9.)

Expansion of the knowledge and information base has been carried out through the combined efforts of governmental units at all levels, academic institutions, and the private sector. Basic and applied research into the scientific processes has been largely the responsibility of federal agencies, academic institutions, and the private sector. Academic and private research is frequently conducted in cooperation with, and supported by, funding from federal agencies. State (other than state-supported academic institutions) and local governments have generally assumed a much smaller role with regard to research, although there are numerous instances of both major research efforts and smaller contributions by state and local governments.

Inventory and measurement, primarily through data collection and mapping, have been more equally distributed among all levels of government, as well as in the private sector and academic institutions. Typically, data are collected at the state and local levels, while the federal government, an academic institution, or a professional or nonprofit organization assumes responsibility for assembling this information into formats useful for discerning regional or national trends or status. In other instances, with regard to data collected through remote sensing techniques, for example, responsibility for both data collection and compilation may be found at the federal level.

The last 25 years have witnessed rapid technological advancement in all disciplines and endeavors, and floodplain management has benefitted from this technological revolution in innumerable ways. Probably most technological advances are so subtle, indirect, or so thoroughly integrated into everyday professional life that they go largely unrecognized. Many technical advances have such widespread application in numerous fields, including floodplain management, that coverage in the *Assessment Report* is not appropriate. Other advances, however, deserve mention because they are still new enough, have resulted in such dramatic changes in floodplain management practices, or are sufficiently specific to floodplain management and closely related fields.

CLIMATE CHANGE AND WEATHER FORECASTING

Both long-term climate changes and short-term weather conditions can have an important effect on floodplain management. Knowledge of long-term climate conditions, particularly precipitation, is needed for design of flood control structures and prediction of flood levels for a given return frequency. Forecasts of short-term weather conditions are needed to prepare for and defend against local flooding.

CLIMATE AND CLIMATE CHANGE

In the past, there was little reason to suspect that any large changes in the climate were imminent. It was therefore assumed that statistical sampling theory could be used to predict important parameters of climate over the next several decades. In fact, one of the basic assumptions of hydrology and floodplain management for most applications has been that long-term climate is constant. That is, climatic conditions will be the same in the future as they have been during the period for which reliable records are available.

Even if the assumptions of a constant climate were correct, the period of direct measurement of climate conditions in the United States is very short. As a result, the confidence that can be placed in these measurements for future planning needs is limited. Because of the short historical record of direct measurement, indirect methods have been developed to extend the climate record. Modern research techniques such as tree ring dating, carbon 14 dating, and archeological investigations have revealed little change in mean climate factors, such as temperature and precipitation, over the past 500 years or so.

Over the past few decades, however, evidence suggests that the climate can change rather quickly (within the time frame of a decade or so) and last for perhaps as long as half a century or more. Therefore, traditional 30-year averages for various climate parameters often fail to adequately describe the climate and may be misleading for decisions involving long-term consequences. Studies revealing no long-term change in mean parameters have shown that short-term variations are common and tend to be cyclical. In addition, short-term cycles often appear within longer-term cycles, making interpretation of data difficult and prediction of future changes problematic.

A recent study (Michaelsen, 1987) illustrates how indirect methods of determining climate variations can provide valuable information for water resources and floodplain management. Tree ring analysis was used to estimate the variability of annual rainfall in central California. The study concludes that, while there have not been any long-term changes in mean annual precipitation over the past 400 years, there have been wide swings in the variability of precipitation over 20- to 30-year periods. In particular, the period 1920 to 1965 had low variability and low precipitation. Although many floodplain management concerns are not affected by annual precipitation, it is noted that:

> *Most of the population growth and dam construction have occurred since the last period of high variability. An increase in variability, and the associated increase in the uncertainty of water availability, could put serious strains on the water impoundment and delivery systems in the area, especially if there is continued growth in population and water demand.* (Michaelsen, 1987.)

Certain gases in the earth's atmosphere trap long-wave radiation emitted from the earth's surface and the result is a global mean temperature of 15°C, as opposed to an estimated -18°C without an atmosphere. This phenomenon is popularly known as the "greenhouse effect" and is necessary for the continuation of human life. By far the most important greenhouse gas is water vapor, but carbon dioxide makes a substantial contribution, and smaller contributions come from ozone, methane, and nitrous oxide (Mitchell, 1990).

During the 1970s and 1980s, evidence increased that human use of fossil fuels was adding to the quantity of greenhouse gases in the earth's atmosphere to such an extent as to cause global climate changes (Karl, et al., 1990). Concentrations of carbon dioxide, methane, and nitrous oxide are all now known to be increasing. In recent years, other greenhouse gases — principally chlorofluorocarbons (CFC) — have been added to the atmosphere in significant quantities.

There are many uncertainties in attempting to predict the consequences of the increase in greenhouse gases on climate. Numerous studies involving complex numerical climate models have been conducted over the past 10 years in efforts to predict these consequences. Due to the many uncertainties involved in understanding climate change, these studies have produced a wide range of results. While most studies predict a significant increase in worldwide average temperatures (global warming), other studies have actually shown a decrease in worldwide average temperatures. Predictions of impacts on specific areas of the earth are, of course, equally uncertain and variable (Mitchell, 1989).

In 1988, the World Meteorological Organization and the United Nations Environment Program created the Intergovernmental Panel on Climate Change (IPCC). The panel was given several important tasks, including: assessing the likelihood of a future climate change due to human activities, particularly the emissions of greenhouse gases into the atmosphere; analyzing the possible impacts of such a change, including socioeconomic impacts; and exploring ways to slow down or stop activities that lead to such changes (Bolin, 1990).

The IPCC Working Group charged with the scientific assessment of climate change presented a number of interesting findings (Intergovernmental Panel on Climate Change, 1990):

- Some greenhouse gases are potentially more effective than others at changing climate, and the relative effectiveness of these gases can be estimated. Carbon dioxide has been responsible for over half the enhanced greenhouse effect in the past and is likely to remain so in the future.

- Atmospheric concentrations of the long-lived gases (carbon dioxide, nitrous oxide, and the Chlorofluorocarbons) adjust only slowly to changes in emissions. Continued emissions of these gases at present rates would commit us to increased concentrations for centuries ahead. The longer emissions continue to increase at present-day rates, the greater reductions would have to be for concentrations to stabilize at a given level.

- The long-lived gases would require immediate reductions in emissions from human activities of over 60% to stabilize their concentrations at today's levels; methane would require a 15-20% reduction.

- Under its scenario for Business-as-Usual emissions of greenhouse gases, the IPCC predicts a rate of increase of global mean temperature during the next century of about 0.3°C per decade (with an uncertainty range of 0.2°C to 0.5°C per decade); this rate is greater than the rate seen over the past 10,000 years. This will result in a likely increase in global mean temperature of about 1°C above the present value by 2025, and 3°C before the end of the next century. The rise will not be steady because of the influence of other factors.

- Under the other IPCC emission scenarios, which assume progressively increasing levels of controls, predicted rates of increase in global mean temperature range from about 0.2°C per decade to about 0.1°C per decade.

- Under the IPCC Business-as-Usual emissions scenario, an average rate of global mean sea level rise of about 6 cm per decade over the next century is predicted (with an uncertainty range of 3-10 cm per decade), mainly due to thermal expansion of the oceans and the melting of some land ice. The predicted rise is about 20 cm in global mean sea level by 2030, and 65 cm by the end of the next century. There will be significant regional variations.

- Global mean surface air temperature has increased by 0.3°C to 0.6°C over the last 100 years, with the five global-average warmest years being in the 1980s. Over the same period, global sea level has increased by 10-20 cm. These increases have not been smooth with time nor uniform over the globe.

- The size of this warming is broadly consistent with predictions of climate models, but it is also of the same magnitude as natural variability. Thus the observed increase could be largely due to this natural variability; alternately this variability and other human factors could have offset a still larger human-induced greenhouse warming. The unequivocal detection of the enhanced greenhouse effect from observations is not likely for a decade or more.

- There is no firm evidence that climate has become more variable over the last few decades. With an increase in the mean temperature, however, episodes of high temperatures will most likely become more frequent in the future, and cold episodes less frequent.

- Ecosystems affect climate and will be affected by a changing climate and by increasing carbon dioxide concentrations. Rapid changes in climate will change the composition of ecosystems;

some species will benefit while others will be unable to migrate or adapt fast enough and may become extinct. Enhanced levels of carbon dioxide may increase productivity and efficiency of water use of vegetation. The effect of warming on biological processes, although poorly understood, may increase the atmospheric concentrations of natural greenhouse gases.

Accelerated Sea Level Rise Due to Climate Changes

As the report of the Intergovernmental Panel on Climate Change indicates, the historical relative rise in sea level is expected to continue over the next century and, as a result of human-induced climate changes, the rate of rise is anticipated to increase. The future rate of relative sea level rise, however, is uncertain. Reports by the U.S. Environmental Protection Agency (EPA) (Hoffman, 1983) and the National Academy of Sciences (NAS) (Revelle, 1983) during the early 1980s examined the effect of atmospheric concentrations of greenhouse gases on relative sea level rise. The NAS report estimated a rise in sea level of 70 cm (2.3 feet) over the next century, given plausible models of atmospheric warming (Revelle, 1983). The EPA provided several estimates/scenarios of global sea level rise to the year 2100. Under the EPA's high scenario, sea level would rise 345 cm (11.3 feet) by 2100; under the conservative scenario, sea level would rise 56 cm (1.9 feet) by 2100. The EPA felt that a global sea level rise between 144 cm (4.8 feet) and 217 cm (7 feet) by the year 2100 was most likely (Hoffman, 1983). The NAS study — *Engineering Implications of Sea Level Rise* (National Research Council, 1987) — based its recommendations on the 70 cm rise projected by Revelle (1983) and curves on either side as the most reasonable envelope of projections for now.

The rate of sea level rise is likely to be higher in some areas than others. For example, the EPA estimated that prior to the year 2000 along most of the Atlantic and Gulf coasts of the United States, the rise will be 18 to 24 cm (0.6 to 0.8 feet) more than the global average. Also, the greatest changes in sea level rise are unlikely to occur until the last half of the next century. All projections were significantly higher than current trends in sea level rise (Hoffman, 1983).

These and other studies of relative sea level rise have indicated the great uncertainty in predicting the timing and levels of sea level rise that may be anticipated. The uncertainty is due both to changing estimates of global warming and likely changes in relative sea level rise in response to global warming. For example, a National Research Council committee in 1985 predicted that sea levels would rise about 1 meter with a 3°C increase in global average temperature by the year 2100. On the basis of information available in 1989, a member of that committee reported that the best predictions now call for a rise of only about one-third meter with the same levels of increase in carbon dioxide. However, the rise is expected to occur before 2100, perhaps by mid-century. The range in these recent predictions varies from a 0.7 meter rise to a 0.1 meter fall in relative sea levels. The lower predictions for global sea level rise primarily reflect new information concerning how the Antarctic climate will respond to global warming. Instead of shrinking as earlier believed, new evidence indicates that the Antarctic ice cap will most likely expand in the coming decades, thereby removing water from the ocean. As one researcher stated "This means our understanding of the system is not very good at the moment" (Monastersky, 1989).

Assuming that global warming occurs and relative sea level does rise, several ways in which sea level rise would likely exacerbate coastal and other flooding have been identified (Titus and others, 1987):

- Decreased hydraulic head and higher water tables would reduce both natural and artificial drainage;
- More areas would be flooded by spring tides;
- Storm surges would be higher;
- Areas that were above sea level and relied on gravity drainage would now be below sea level and have to rely on pumping;
- Wetlands will be lost in many locations where they are blocked from migrating inland by structural erosion or flood protection measures, or by other types of development and natural landforms; and
- Increased precipitation in some areas may increase flood frequencies.

Long-Term Precipitation Data

Historic precipitation data are the basis for almost all floodplain studies in the United States where streamflow data are not available. The primary agency for the collection and archiving of precipitation data is the National Weather Service (NWS).

Twenty five years ago, the U.S. Weather Bureau, now the NWS, planned for one precipitation gage per 625 square miles for climatological purposes, and about 80% of the planned gages were established. For hydrologic purposes, one gage was recommended for every 100 square miles, and for thunderstorm analysis and flood warning, one gage every square mile (Chow, 1964). In comparison, the *Precipitation-Frequency Atlas of the Western United States*, published by the NWS in 1973 and widely used in 11 western states for hydrologic forecasting, used data from only 38 recording rain gages, a density of only one gage per 3,100 square miles. In the mid-1980s, the NWS operated only 29 such gages in Arizona, and fewer than 40 NWS recording rain gages were in operation in Utah and Nevada (Reich, 1988).

Throughout the rest of the United States, the *Rainfall Frequency Atlas of the United States* (Hershfield, 1961) remains in widespread use. This atlas utilizes data collected from the earliest available records through 1957 for nonrecording stations, and through 1958 for recording gages. The average length of record for the longest, nonrecording data was 48 years, and for recording gages only 16 years.

Because of cyclical precipitation patterns noted previously, the limited number of gages used, and the short length of record of most gage stations, rainfall atlases may not accurately reflect long-term precipitation frequency. Frequency estimates may be high or low depending on the known precipitation patterns during the limited period of record relative to longer, unknown precipitation patterns.

WEATHER FORECASTING

The National Weather Service is the federal agency with primary responsibility for the collection and analysis of weather data useful for floodplain management. With regard to riverine flooding, precipitation and temperature data are most often used, while for coastal flooding, wind data are generally most critical. The actual or forecast intensity, extent, and duration of precipitation is used, sometimes in conjunction with streamflow data, to forecast flooding.

The NWS operates a data collection system that consists of about 230 stations in the 50 states, Puerto Rico, and across the Pacific Ocean. Most of these stations take both synoptic and base observations. At locations where data cannot be collected efficiently by NWS personnel, automated weather stations are installed. The NWS operates about 165 automated stations in the 50 states and offshore. In addition, the NWS contracts for data collection at about 170 stations, mostly within the 50 states, and the Federal Aviation Administration (FAA) staffs more than 200 observation stations from which weather data are collected and provided to the NWS. In marine locations where observations cannot be made effectively by staff, automated moored and drifting data buoys are used. These data buoys collect data on several parameters and relay those data by a variety of means, including several satellites.

To provide near real-time data of river stage and rainfall, a network of Automatic Hydrologic Observing System (AHOS) stations is operated throughout the 48 conterminous states and Alaska. Approximately 450 of these sites are automatically interrogated by telephone every six hours, and an additional 67 stations automatically transmit data via satellite.

The NWS operates 128 weather radar stations that provide information on areal coverage, height, intensity, and movement of storms for warning, forecasting, hydrological, and climatological programs.

Other data are collected by the NWS from a variety of sources. There are over 1,300 ships that report data systematically, and 300 other ships report data whenever they are in waters covered by NWS forecasts. The Solar Radiation Program collects data from 38 stations in the United States, Guam and Puerto Rico (National Weather Service, 1985).

STREAMFLOW DATA

The vast majority of the stream gages in the United States are operated by the U.S. Geological Survey (USGS). In 1990, for example, the USGS operated 7,363 daily record stations. With very few exceptions, the stream gages operated by the USGS are a cooperative effort. That is, a local sponsor — which may be another federal agency, a state or local agency, or another organization — pays for part of the operation of each station. For this reason, the addition or removal of a stream gage from the network is generally decided by the local sponsor. As a result, there is no overall consistency to this aspect of data collection which is subject, in large part, to budget problems and political decisions made by the hundreds of local cooperating agencies (Colson, 1991).

Since the first USGS stream gage was established in 1889, the USGS stream gage network increased through 1980, but has declined since, largely due to reductions in funding by local cooperators. Significantly, the number of stations with 21 or more years of data has remained almost constant over that time, which means that stations with relatively long records are being discontinued.

Almost all of the stream gages are located on larger watersheds. Of 846,000 tributaries in the United States with drainage areas between one and two square miles, fewer than 60 were gaged (Reich, 1988). Yet, knowledge of runoff from small watersheds is important for many purposes, including highway drainage design[1] and urban drainage analysis, and runoff from these watersheds cannot be accurately extrapolated from data for larger watersheds because the runoff processes and storms are different for small watersheds.

To partially fill this important gap, the Agricultural Research Service (ARS) has gaged hundreds of plot-sized watersheds to measure runoff associated with individual land uses and soils. Comparative runoff plots are generally located at state land-grant universities or at ARS research centers scattered around the United States (von Wolffradt, 1989).

The United States Section of the International Boundary and Water Commission, United States and Mexico, operates stream gages on the mainstem and tributaries of the Rio Grande, the Colorado River, the Tijuana River, and several streams crossing the Arizona-Sonora, Mexico boundary. The operation of these gages is mandated through treaties and other agreements between the United States and Mexico and is funded totally with federal monies. The streamflow data have been published annually since 1931 for the Rio Grande and its tributaries, and since 1950 for the Colorado River and the other western boundary streams (International Boundary and Water Commission, 1989).

Water data have been published annually by the USGS since 1890. Records furnished by other agencies are included in the reports when they supplement USGS data and appear to be consistent and reliable. Streamflow and water level data have been placed in computer files for efficient storage and retrieval since 1956 (Thomas, 1977). Currently, data from USGS surface-water records are published annually for each state and maintained on a computerized data base — the National Water Data Storage and Retrieval System (WATSTORE).

All types of water data are accessed through WATSTORE. The data are grouped and stored in five files, depending on common characteristics and data collection frequencies. The five files are:

1) STATION HEADER FILE: an index for the 320,000 water data storage sites;
2) DAILY VALUES FILE: more than 240,000,000 daily parameters such as streamflow, ground-water levels, specific conductance, and water temperatures;
3) PEAK FLOW FILE: 460,000 records on annual maximum streamflow and gage height values;
4) WATER QUALITY FILE: 2,300,000 analytical results that describe biological, chemical, and physical water characteristics; and

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[1] During the late 1960s and 1970s when the federal highway construction program was very active, the USGS operated crest-stage gages in many basins of 1-2 square mile drainage area (Colson, 1989).

5) GROUND-WATER SITE-INVENTORY FILE (independent but cross-referenced to Daily Values and Water Quality Files): data on 850,000 sites (construction history, geohydrologic data, and one-time field measurements) (Dodd, undated).

Another major source of streamflow data is STORET, EPA's water quality data base. STORET is a computerized database system maintained by the EPA for storage and retrieval of data relating to the waterways within and contiguous to the United States. This centralized database includes nationwide data on water quality, water quality standards, point source pollution, fish kills, waste abatement needs, etc. The system is used by federal, state, and local water quality agencies (Melanson, 1988).

HYDROLOGY AND HYDRAULICS

The availability and ease of use of inexpensive computers have allowed great progress in the application of accepted methodologies for hydrologic and hydraulic analysis. The potential impact of small scale development plans (even plans for single structures) on flooding and the susceptibility of proposed development to flooding can today be evaluated more quickly and inexpensively than in the past. At the same time, the methodologies themselves can be more easily and inexpensively evaluated.

Today, computer programs are readily available to evaluate such widely accepted techniques as the Log-Pearson Type III analysis of streamflow data. Researchers and a few practitioners are using two- and three-dimensional analysis of flood flows to obtain more realistic and reliable results for some conditions than are obtainable from the "step-backwater analysis." Sediment transport models are being developed, calibrated and applied in many areas.

These various computer-aided techniques allow the development of large area hydrologic and hydraulic models to evaluate the effects of future urbanization, structures, and other land-use changes. Only a decade ago, these activities were undertaken only at great expense, and were therefore applied infrequently.

While the computer revolution has improved many aspects of the sciences of flood hydrology and hydraulics, it has also opened the door to misuse of the standardized techniques by persons and organizations not fully cognizant of the assumptions and limits inherent in those methods (Pilgrim, 1986).

HYDROLOGY

Hydrology is the science dealing with the properties, distribution, and circulation of water on the surface of the land, below the surface, and in the atmosphere. Hydrologic parameters of importance to floodplain management include: flood peak flows; flood volumes; time of concentration and travel; rate of rise; water velocities; sedimentation and degradation of flood channels and floodplains; flood elevations; the effect of geomorphology on floods and vice versa; the hydraulics of flood channels, floodplains, and man-made structures; and water quality as it is impacted by floods.

Peak flows are the basis for most aspects of floodplain management. From an analysis of the peak flow at a particular point on a stream, flood elevations may be computed using various hydraulic analysis techniques. The primary methods for computing peak flows are contained in *Guidelines for Determining Flood Flow Frequency* (Bulletin 17B) (U. S. Water Resources Council, 1981). These methods are recommended for flood insurance studies performed by study contractors for the Federal Emergency Management Agency (FEMA), and by most states and communities that have developed hydrologic procedures for floodplain management purposes.

The U.S. Water Resources Council (WRC) methodology recognizes four categories of flood peak data: 1) systematic records, from which annual peak flows may be derived; 2) historic data on floods; 3) comparisons of streams with similar watersheds; and 4) the estimation of runoff from precipitation.

Systematic records and historic data are generally subjected to an analysis to determine the statistical characteristics of the data. These characteristics are assumed to represent all floods at that location. The analysis most often used assumes a "log-Pearson Type III" (LPIII) distribution of the data.

Comparisons of streams with similar watersheds starts with gage data from a stream or a number of streams. Flows in ungaged streams are assumed to have similar statistical characteristics, providing that differences in watershed characteristics are properly accounted for. Generally, a multi-variate regression analysis is used to determine the relative importance of various watershed characteristics.

"Exceedance probability" is determined from historic flood data and is based on a statistical analysis that estimates the average frequency with which a flood of a particular magnitude will be exceeded. This term may be expressed as the probability that a flood will be exceeded in any year (the "annual exceedance probability"), or as the average recurrence interval (the "n-year flood"). A flood with a .02 annual exceedance probability has a two percent chance of being exceeded each year (and is also called a "50-year" flood).

The exceedance probability methodology can be used to:

- Set a design standard (e.g., new facilities must be safe from the one percent annual chance flood);
- Evaluate a historic flood (e.g., the flood of 1967 has a four percent chance of being exceeded each year); or
- Evaluate an existing policy or structure (e.g., this levee reach provides protection against a 10 percent annual chance flood event).

The methodology is used for many aspects of flood hydrology that directly and indirectly affect flood losses. For example, at a given point on a stream, it is possible to calculate a variety of one percent annual chance floods depending on which aspect of flooding is important for management purposes. For example, floods that produce the highest instantaneous flood peak, the largest flood volume, and the longest period of flow above a certain quantity can be calculated. The hydrology of those three different floods will be critical for the development of elevation standards, reservoir design, and levee design, respectively.

The estimation of runoff from precipitation (precipitation/runoff analysis) uses knowledge or assumptions about the hydrologic characteristics of a watershed to estimate the runoff from a real or theoretical storm. Those characteristics and their inter-relationships are generally mathematically modelled in a computer program. The most widely used computer models for rainfall/runoff analysis of flood peaks are the TR-20 developed by the Soil Conservation Service (SCS), and the HEC-1 developed by the U.S. Army Corps of Engineers (Corps). For small urban drainage areas, the SCS developed a methodology to be applied manually — the TR-55 method. This method has recently been adapted to a computerized format. For urban drainage where water quality is a concern, the EPA has developed the Stormwater Management Model (SWMM).

HYDRAULICS

Surface water hydraulics — the mechanical properties of water in motion — are basically controlled by a relatively few parameters: slope, surface roughness, depth of flow, channel shape and size, and sediment load. Each of these parameters is interrelated, so that the effect of slope is generally measured while holding the other parameters constant, and so forth. The effects of most of these parameters are only estimated by empirical methods.

The most widely used method for calculating river hydraulics is the "step-backwater analysis." This method uses channel and overbank topography and other hydraulic parameters to maintain continuity of mass and energy from one river cross section to the next. The step-backwater analysis is usually computerized, and may include separate analysis methods for bridges, weir flow, channel modifications and other special features. The most widely used computer model is HEC-2, developed by the Corps' Hydraulic Engineering Center (HEC). Other step-backwater models in general use include the WSP-2 developed by the SCS and the WSPRO developed by the Federal Highway Administration (FHWA).

Where the expense of a backwater analysis is not justified or affordable, a simple computation is frequently used for a single point on a stream. This computation — the Manning equation — can give acceptable results if there are no obstructions downstream that cause a backwater effect. For areas of shallow flow, the Manning equation is generally used because backwater is considered to be a relatively small influence compared to surface roughness.

In some cases, where hydrologic conditions and channel configurations are similar over a large geographic area, flood depths at a number of existing stream gages are used to estimate flood depths on other streams that have no gages. This procedure is used for floodplain management purposes where it is not economically feasible to perform expensive detailed studies. The resultant estimates, however, are not necessarily accurate.

A special model has been developed by the National Weather Service for estimating inundation from dam breaks. This DAMBREAK model uses kinematic wave theory to determine flood heights and is widely used by different federal and state agencies as well as private engineering organizations.

Substantial progress has been made with regard to the modelling of coastal and riverine flooding. Coastal flooding is basically a hydraulic process driven by wind and tide effects on open water, by bathymetry and onshore topography, and resultant wave action. The first coastal flooding model to receive widespread application was the "Special Program to List Amplitudes of Surges from Hurricanes" (SPLASH) developed by the NWS. This model was used for initial mapping of coastal flood zones under the National Flood Insurance Program (NFIP). About 1975, the SPLASH model was replaced by a more sophisticated model called "Sea, Lake and Overland Surges from Hurricanes" (SLOSH), that can be used to model inundation areas from hurricanes of a particular magnitude, forward speed, and track.

FEMA and the Corps of Engineers have developed several models and methodologies used for mapping the one percent annual chance flood in coastal areas. The Coastal Flooding Storm Surge Model is used for determining stillwater flood elevation from hurricanes along the Atlantic and Gulf coasts. Other models or methodologies may be used in conjunction with or instead of this model. For example, models or methodologies have been developed to supplement the basic storm surge model by adding the effects of wave height onto stillwater flood elevation (WHAFIS), adding the effects of wave runup, and accounting for impacts of marsh grass on floods. Other models have been developed to address flooding on the Great Lakes, flooding from Tsunamis, Chubasco flooding in Southern California, Pacific Northwest storm flooding, and "northeaster" flooding in the northeastern United States. (Federal Insurance Administration, 1985).

FLOOD FORECASTING, WARNING AND RESPONSE

Efforts to forecast riverine and coastal flooding and to warn populations at risk have contributed greatly to the expansion of floodplain management capabilities. Historically, most of these efforts have been carried out by the National Weather Service. More recently, private weather forecasting efforts have also made important contributions.

FLOOD FORECASTING, WARNING AND RESPONSE FOR RIVERINE FLOODING

Historically, most flood warning efforts in the United States focused on larger river basins where timely and accurate forecasts were possible using the available technology. Hydrologic models for use on these large river systems were developed by the NWS through its River Forecast Centers. Data on antecedent conditions, rainfall, and river stages could be combined in the NWS models to predict the magnitude, time and duration of flood peaks.

On hundreds of smaller streams, the NWS works with local communities to help establish self-help flood warning systems (National Weather Service, 1985). These cooperative systems rely on a network of community volunteers to make regular observations of rainfall and/or river levels and to telephone their observations to the appropriate NWS office. The NWS uses the data gathered by the volunteers, along with its own data on soil moisture conditions and precipitation forecasts, to run a hydrological model of the river basin and predict the time and level of flooding. While very effective in some communities, these programs have inherent limitations. Most notably, observers are not always available to collect and report data on precipitation and river levels, particularly during the night and at remote locations.

Recognizing these limitations, the NWS began developing an automated flood warning system in the late 1970s. The automated system was designed to take advantage of technological advances that permit real-time collection and transmittal of meteorological and hydrological data from remote locations to populated areas at risk.

The resulting system was called Automated Local Evaluation in Real Time (ALERT). The completely automated ALERT system does not rely on volunteer observers. Its major components are: precipitation gages, river gages, radio transmitters, radio receivers, data encoders and decoders, a microcomputer, and specially designed software to process the data. Remote rain gages automatically collect data on amounts and rates of rainfall and transmit this information via VHF radio to a base station. Similarly, stream gage stations transmit data on the rise in river levels. The data collection and transmittal from remote locations is generally battery powered. Because the system is designed for "event reporting" (data transmitted only when there is a predetermined amount of rainfall or change in stream level), batteries can last a year or more without recharging.

When predetermined critical precipitation and/or stream level values are reached, an alarm is triggered at the base stations and personnel are placed on alert to monitor the situation closely. Using the rainfall and river rise information, combined with precipitation forecasts and a hydrologic model of the stream, NWS personnel are able to accurately forecast floods and provide downstream officials and residents with increased warning time. Since the information is also received at a local base station, local officials can, if necessary, initiate flood warnings without waiting for a forecast from the NWS. The increase in warning time afforded by the automated system is often sufficient to permit emergency actions that can save lives and reduce property losses.

ALERT systems were initially used in the western United States where sudden rainstorms in the remote, upper reaches of watersheds can cause flash floods in the lower parts of the watershed where no rain may have fallen. ALERT systems have now been successfully installed in dozens of locations throughout the United States, and many more are under development. While the original ALERT system was developed by the NWS, several private firms have now developed similar systems (L.R. Johnston Associates, 1986).

Another type of automated flood warning system developed to serve parts of the Appalachian region is known as the Integrated Flood Observing and Warning System (IFLOWS). This system is more regional in scope than ALERT systems, more dependent upon NWS warnings, and provides less opportunity for warnings to be issued by local communities. Recently, some elements of ALERT-type systems have been incorporated into the IFLOWS.

The availability of inexpensive, highly capable minicomputers and microcomputers is currently making possible a great increase in the number of flood forecasting systems designed for smaller watersheds. The true effectiveness of these systems, however, has yet to be fully tested.

FLOOD FORECASTING, WARNING AND RESPONSE FOR COASTAL FLOODING

Flood forecasting, warning, and response for coastal area flooding has focused on the observation, measurement and tracking of tropical cyclones and tsunamis.

Technical Advances for Observing Tropical Cyclones

Tropical cyclones spend most of their lives over warm ocean waters and derive much of their energy from those waters. Before aircraft reconnaissance and weather satellites, the detection of tropical cyclones was dependent on chance encounters with shipping or populated areas. The first radio weather report from a ship underway was received in 1905. In the years that followed, the amount and quality of marine weather data gradually increased. By 1959, the number of observations from ships during the June to November hurricane season exceeded 64,000. The number has increased less rapidly since the early 1960s, but this is due to changes in the characteristics of the shipping industry.

Technological advances since World War II have resulted in more precise tropical cyclone detection, positioning, and intensity determination. Improved equipment for measuring weather conditions above the earth's surface have provided additional knowledge of factors affecting tropical cyclone motion and intensity. The use of aircraft to obtain data inside hurricanes was found to be feasible in 1943, and U.S. Air Force and Navy[2] aircraft have made routine reconnaissance of tropical cyclones since 1944. Before the operational availability of satellite data around the mid-1960s, these flights were especially important for the early detection of storms.

An important product of the National Aeronautic and Space Administration (NASA) space program has been the development of weather satellites — now the standard observational tool for the detection and monitoring of tropical cyclones. Systematic procedures have been developed to estimate the location of the center and intensity of the storm. There is now a high probability that the center (eye) of the storm can be located within 25 nautical miles of its actual position, and that the intensity can be determined to within 10 knots of actual intensity. Satellites also provide the means of obtaining direct or indirect measurements of other environmental conditions around the storm, including wind, temperature, moisture, and rainfall conditions.

Although the first pictures of a tropical cyclone were transmitted by the polar orbiting TIROS-I satellite in 1960, it was not until 1966 that the first completely operational weather satellite, ESSA-I, was placed in orbit. The ESSA satellites orbited the poles and provided views of tropical cyclones once per day. By the late 1960s, geostationary satellites allowed continuous daytime surveillance. The nighttime viewing gap was closed in 1974 with the launch of the first Geostationary Operational Environmental Satellite (GOES). Since the introduction of continuous weather satellite surveillance, there is little chance that a tropical cyclone will go undetected.

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[2] Navy hurricane reconnaissance was discontinued after the 1974 hurricane season.

Aircraft reconnaissance is still needed, however, to obtain supplemental and more precise environmental data from in and around the storm area. In addition to military aircraft reconnaissance, several aircraft with sophisticated instrumentation for the collection of detailed data are operated by the National Oceanic and Atmospheric Administration (NOAA). These aircraft are used primarily for research purposes but are also useful for operational tracking of tropical cyclones. A significant milestone occurred during the 1977 hurricane season when the Aircraft Satellite Data Link (ASDL) communications system enabled measurements taken at 60-second intervals inside a storm to be transmitted from the aircraft to the National Hurricane Center (NHC) and plotted by computer within a few seconds.

An extensive network of powerful coastal radars is now in operation. Radar is particularly useful in detecting sudden changes in the direction of tropical storms within 250 miles of the radar site. This permits "last minute" adjustments in community preparedness efforts as the storms move ashore.

In recent years, marine meteorological data buoys have been developed and deployed. These floating data platforms are anchored at strategic locations and transmit observations of wind, pressure, waves, and ocean and air temperatures in and around tropical cyclones and other weather systems (Neumann, 1987).

Although the technology for observing hurricanes has improved in recent years, the science of predicting the movement of these tropical cyclones has shown little improvement. The standard error in a 24-hour forecast of landfall is about plus or minus 100 miles.

Technical Advances for Observing Tsunamis

The need for a tsunami warning system became apparent following the 1946 tsunami that devastated Hilo, Hawaii, and this need became even more urgent after the 1964 "Good Friday" tsunami in Alaska. As a result of these events, a warning system was developed that has been expanded and refined over the years into a comprehensive international tsunami warning system coordinated by the NWS. At the Pacific Tsunami Warning Center (PTWC) at Ewa Beach, Hawaii, a 24-hour watch is maintained on a network of tide gages and seismograph stations throughout the Pacific. Whenever an earthquake of sufficient magnitude to generate a tsunami (at least magnitude 7.5 on the Richter Scale in the Pacific and 7 along the Pacific coast of Alaska) is detected, NWS personnel work closely with personnel of the USGS at the National Earthquake Information Center (NEIC) to determine the epicenter and focal depth of the earthquake.

If the epicenter of the quake is under or near the ocean, and if its focal depth is less than 20 miles deep, tsunami generation is possible. With this first seismic information, the warning center issues a WATCH, which alerts participating emergency forces and the general public that a dangerous earthquake has occurred, and that the possibility of a tsunami exists. Then the warning system turns to its second line of detection, the Pacific-wide network of tide stations.

When a tsunami is confirmed by tidal gages that can distinguish the "signature" waves of tsunamis from other types of waves, a tsunami WARNING is issued. This warning alerts all participants to the approach of potentially destructive waves and gives the estimated arrival times for all locations.

In recent years, automation and computer and satellite communications technology have dramatically reduced the time between the detection of a tsunami-generating earthquake and the issuance of watches and warnings. The GOES satellite, for example, has significantly reduced the transmission time of sea level and tide data from remote gages in the Pacific. At one time, it took a few hours to receive data from South America because of communications delays. Now, the data are received at PTWC in a few minutes from a GOES sea-level network of 26 remote stations that stretches across the Pacific from Wake Island to Guadalcanal to Easter Island, and along the coast of South America.

Difficulties in tsunami forecasting remain, however. Even when a tsunami is confirmed by tidal gages, the exact size of the waves is not known nor is the potential for destruction at any given site (Forrester, 1987).

PRIVATE WEATHER FORECASTING

Weather forecasting was previously almost the sole responsibility of the NWS. Most NWS weather data (both mesoscale and microscale data), however, is now available to private interests at a modest cost. Consequently, many private weather forecasting businesses have been established over the past 20 years or so. Although private weather forecasting is dominated by a few very large companies that cover the entire country, dozens of smaller companies now also provide forecasts.

Typically, the private companies obtain weather data directly from NOAA/NWS computers and serve such specialized interests as: local TV and radio stations, public works departments, school districts and other municipal offices, as well as private industries (shipping and agricultural industries, for example) with weather-dependent concerns. The advantage that private weather services can offer these interests is preparation of weather forecasts customized for a particular location and/or time.

TOPOGRAPHIC MAPPING

Topographic information is one of the basic information requirements for floodplain management and the development of floodplain maps. Topographic maps formed the basis for preparation of early floodprone area maps, and in areas where detailed floodplain maps have not yet been prepared, topographic maps are still used to delineate approximate limits of floodplain areas.

The U.S. Geological Survey has been mapping the country for more than a century. Today, most of the conterminous United States and Hawaii have been mapped at a scale of 1:24,000 (7.5 minute series) with contour intervals of five to ten feet (contour intervals are greater in mountainous locations). Alaska is mapped at a scale of 1:63,360 (15-minute series). As shown in Table 6-1, topographic maps at a scale of 1:24,000 are expected to be published by the end of Fiscal Year 1991 for all states except Alaska. All but a few sections of Alaska were expected to be completed at a scale of 1:63,360 by the middle of 1990 (Kelley, 1990). Much of the standard topographic mapping is done on a cooperative basis by the USGS and state agencies. Local governments often prepare more detailed topographic maps, with scale and contour intervals determined by local conditions.

The USGS is now beginning to convert existing topographic map information to a digital database.

Table 6-1. Estimated Completion of Primary Topographic Mapping for the United States.

STATE	YEAR PUBLISHED OR FY TO PRINTING	T-MAPPING
Alabama	1987	0
Alaska**	1990 (C-Jun90)	0
Arkansas	1987	0
Arizona	1988	160 (3rd Quarter FY91)
California	1990 (C-Jun90)	61 (2nd Quarter FY91)
Colorado	1987	0
Connecticut	1951	0
Delaware	1951	0
Florida	1978	0
Georgia	1978	0
Hawaii	1980	0
Idaho	1990 (C-Jun90)	85 (3rd Quarter FY91)
Illinois	1987	0
Indiana	1966	0
Iowa	1986	0
Kansas	1981	0
Kentucky	1957	0
Louisana	1989	0
Maine	1990 (C-Apr90)	0
Maryland	1958	0
Massachusetts	1950	0
Michigan	1988	0 (C-Sep89 P-Feb90)
Minnesota	1984	0
Mississippi	1989	0
Missouri	1988	0
Montana	1989 (C-May89 P-Mar90)	7 (3rd Quarter FY91)
Nebraska	1990 (C-Mar90 P-Apr90)	0
Nevada	1990 (C-Jun90)	157 (3rd Quarter FY91)
New Hampshire	1989 (C-Oct89 P-Mar90)	0
New Jersey	1958	0
New Mexico	1988	16 (4th Quarter FY90)
New York	1990 (C-Jun90)	0
North Carolina	1988	0
Ohio	1963	0
Oklahoma	1985	0 (C-Dec89 P-May90)
Oregon	1990 (C-Jun90)	20 (3rd Quarter FY90)
Pennsylvania	1973	0
Rhode Island	1958	0
South Carolina	1990 (C-Jun90)	0
South Dakota	1985	0
Tennessee	1983	0
Texas	1985	0
Utah	1990 (C-Jun90 P-Jul90)	71 (3rd Quarter FY91)
Vermont	1989 (C-Nov89 P-Feb 90)	0
Virginia	1972	0
Washington	1990 (C-Jun90)	8 (3rd Quarter FY91)
West Virginia	1978	0
Wisconsin	1985	0
Wyoming	1989 (C-Jul89 P-Jan90)	0

* Maps compiled at 1:24,000-scale standards, published in 15' format, now being converted to 7 1/2 minute format. Quarter date is the estimated time of completion by the mapping centers.

** Primary mapping is 1:63,360-scale 15' format. Estimated date does not include the Aleutian Islands or St. Lawrence and St. Matthews Islands, nor does it include 9 quads east of Unimak Pass (mainland) where NMD has perennial problems in obtaining photography.

C = Completed-mapping center date

P = Published date

Source: U.S. Geological Survey, Office of Production Planning and Analysis. 1990.

SOILS IDENTIFICATION AND MAPPING

The identification and mapping of soils was initially undertaken in support of agricultural needs, but soils maps and data have proven useful for a great many purposes, including the identification of floodplains and wetlands. For instance, many of the early maps of floodprone areas used in the initial stages of the National Flood Insurance Program were based on soils information. Due to the availability of soil surveys for the entire state, the State of Connecticut established an inland wetlands protection program in 1974 that delineates wetlands strictly on the basis of soil types that are designated as poorly drained, very poorly drained, or floodplain and alluvial (Cooper, 1984).

Soil surveys in the United States have been prepared since the late 1800s, but the "modern" soil survey using improved techniques and standards began in the mid-1950s. Identification and mapping of soils is performed under the National Cooperative Soil Survey (NCSS), and the Soil Conservation Service is the agency charged with classifying and mapping soils on nonfederal land in the United States. By 1983, maps were available for about two-thirds of the land area of the United States (excluding Alaska), or nearly 1.3 billion acres (Powell, 1983). At the end of fiscal year 1990, the SCS expects to have mapped just over 1.625 billion acres (Calhoun, 1990). The SCS has established a goal of completing soil surveys for the entire country by the year 2000 (Rohahey, 1987), and is currently mapping at the rate of about 40 million acres per year (Calhoun, 1990).

During the 1960s and early 1970s, soil survey field work progressed much more rapidly than publication of the surveys. Increased use of computerized data bases and word processing and USGS orthophotography has enabled the SCS to speed the publication of soil surveys. For example, the number of publications increased from 31 in 1970 to 133 in 1979 and 1980 (Powell, 1983).

While enormous progress has been made in the development and publication of soil surveys, improvements are needed in several areas. For example, map scales vary from state to state, the level of detail of soil classification varies, and in many instances supporting information is inadequate or nonexistent. Along most state boundaries the delineations of soil map units and the composition of the units do not match (McCracken, 1984).

In an effort to address these and other problems, a committee of the NCSS recommended in March of 1983 that a nationally consistent general soil map geographic data base be established. In response, the SCS is beginning to digitize existing soil surveys, and hopes that most of the remaining soil survey maps can initially be prepared using digital methods, instead of mapping first with conventional methods then converting to a digital base.

The SCS has examined the possibilities of a centralized program for map digitizing, but there is currently no central directive establishing priorities for digitizing soil surveys. Each state SCS office working with local officials determines the relative importance of digitizing soils maps. Most current digitizing efforts are being conducted on a pilot basis for specific projects and to determine the best procedures. Among the states that have active soils digitizing programs are New Jersey, Vermont, New York, Connecticut, and North Carolina.

The central office of the SCS has been testing different types of digitizing software, and is currently operating seven pilot test sites in its state area and field offices to test different applications of this software. There is also a cooperative agreement with the University of Missouri to develop and scan soil surveys (Rohahey, 1987).

MAPPING OF FLOOD HAZARDS

The delineation of floodplains on maps is a basic necessity for floodplain management. Floodplain maps support a variety of structural and nonstructural flood damage reduction measures and are useful in helping to identify and support decision-making with respect to many floodplain natural values.

Prior to the enactment of the National Flood Insurance Act (NFIA) in 1968, federal floodplain mapping activities consisted of the programs of the Corps of Engineers, SCS, USGS, and the Tennessee Valley Authority (TVA). There was no national standard for preparing floodplain maps, and each agency mapped floodplains according to their individual authorities and missions. Some mapping was done on a project-by-project basis or following major floods, but most mapping was for systematic use in assisting state and local floodplain management efforts.

EARLY MAPPING

Some of the tools of "modern" floodplain management were applied to certain types of floodplain activities during the first part of this century. Particularly in the area of public works, including the design of transportation facilities, there was attention to the return periods of floods, flood elevations, and scour potential. For safety purposes, dams and spillways were sized to pass large, infrequent floods; and culverts were either designed using hydrologic computations or local flood experience. Although several federal agencies had developed techniques for estimating flood peaks, uniform standards for floodplain development were not used by most local planners.

In an early effort to assist community planners manage floodplain development, the TVA began mapping floodplains in 1953 (Tennessee Valley Authority, 1983). The Corps of Engineers, SCS and USGS began producing floodplain maps a short time later.

Tennessee Valley Authority Mapping

The flood hazard information developed by the TVA for the early reports included data on historical floods and on a hypothetical flood that was termed the "maximum flood of reasonable regional expectancy." The development of the hypothetical flood led to numerous problems regarding its potential application for local land-use planning purposes. The unwieldy name — "maximum flood of reasonable regional expectancy" — hindered its acceptance for regulatory purposes; the regional areas used in its determination were poorly defined; the flood event was very large; and it would be expected to occur very infrequently. As a result, many local officials would not accept this hypothetical flood as the basis for regulating floodplain land-use, and state planners considered it to be too large a flood to be reasonable for local planning efforts.

On the other hand, the TVA was hesitant to develop a lesser flood measure since this might imply that it was recommending a lesser planning standard for all aspects of floodplain management. A decision was finally reached to compute two hypothetical floods — a "maximum probable" flood and a "regional" flood. The maximum probable flood was used at that time by the TVA in the design of TVA flood control works. The maximum probable flood was approximately equivalent to the Corps of Engineers' standard project flood, and was generally somewhat larger than the TVA's flood of "reasonable regional expectancy." Determining the flood of "reasonable regional expectancy" involved defining a flood comparable in magnitude to the largest known floods on similar streams within 60 to 100 miles of the stream reach under study.

The regional flood for most streams studied was significantly smaller than the flood of reasonable regional expectancy or maximum probable flood, and rapidly became the standard for floodplain regulations within the Tennessee Valley. TVA engineers felt that the regional flood was large enough for that use, and the state planners felt that it was defensible as fair and reasonable since it was based on actual flood occurrences in the vicinity of the studied streams. As a result, the regional flood was more rapidly comprehended by local officials and citizen members of the planning commission who would ultimately be called upon to enforce the regulations.

Except for the addition of the regional flood, the basic data contained in the TVA's flood hazard information reports did not change substantially until the mid-1970s. At that time, the TVA began to include the "100-year" (and sometimes the "500-year") flood profiles and flooded areas in the reports, generally in response to requirements of the National Flood Insurance Program (Wright, 1989). As shown in Table 6-2, through 1988 the TVA had published 238 Flood Hazard Reports (Tennessee Valley Authority, 1988).

Soil Conservation Service Mapping

The Soil Conservation Service began cooperative floodplain mapping efforts with other agencies in 1936. Following passage of the Small Watershed Program in 1954, formal studies were carried out in coordination with other federal and local agencies. Through September 1988, 260 Cooperative River Basin Studies and 442 Flood Plain Management Studies had been completed. Of the Cooperative River Basin Studies, 245 had a flooding component and flood hazard maps were developed for about 120 of these studies. All of the Flood Plain Management Studies resulted in the preparation of flood hazard maps for the rural communities studied (von Wolffradt, 1988).

U.S. Geological Survey Mapping

The Geological Survey initiated special flood studies in 1902 with a report on the Passaic River flood in northeastern New Jersey. The concept of the flood magnitude-frequency relationship was introduced around 1913. In 1959, the USGS began publishing flood maps, and its 1961 flood atlas for Boulder, Colorado was the first atlas to show boundaries for the "25-year," "50-year," and "100-

year" floods. The USGS has published over 13,000 maps of communities with known flood problems (Haupt, 1988).

U.S. Army Corps of Engineers Mapping

In 1960, Congress specifically authorized the Chief of Engineers to compile and disseminate information on floods and flood damages, and to develop general criteria for the use of floodplain areas. As part of this authorization, the Corps of Engineers initiated the flood plain information study program in 1962 to provide engineering assistance to local interests. In 1966, the Corps' authority was expanded to include the provision of information and technical assistance to other federal agencies.

Also, Executive Order 11296 specified the Secretary of the Army as the primary source of floodplain information to be used in locating federal facilities and disposing of federal lands. Between 1963 and 1976, the Corps completed about 2,000 floodplain information studies (including delineations and profiles) for about 4,000 places and prepared over 500 special flood hazard reports. These studies and reports were used for a wide range of floodplain management and flood control activities (Flood Plain Management Services, 1988).

Table 6-2. Community Flood Hazard Reports Prepared by the TVA, 1954-1988.

YEAR	NUMBER PUBLISHED	YEAR	NUMBER PUBLISHED
1954	8	1971	2
1955	8	1972	4
1956	10	1973	3
1957	27	1974	4
1958	13	1975	6
1959	14	1976	1
1960	18	1977	0
1961	13	1978	1
1962	11	1979	0
1963	7	1980	0
1964	11	1981	2
1965	8	1982	4
1966	11	1983	10
1967	8	1984	3
1968	6	1985	3
1969	6	1986	5
1970	4	1987	4
		1988	3

TOTAL REPORTS PUBLISHED: 238

Note: In addition, 322 flood insurance studies have been prepared for the FIA.

Source: Tennessee Valley Authority. December 1988.

MAPPING FOR THE NATIONAL FLOOD INSURANCE PROGRAM

Mapping for the National Flood Insurance Program is carried out principally by the Federal Insurance Administration (FIA), the Corps of Engineers, the Soil Conservation Service, the Tennessee Valley Authority, the U.S. Geological Survey, and the states and communities participating in the NFIP.

Federal Insurance Administration Mapping

Federal mapping of floodplains for the NFIP began in 1968 when the FIA set about identifying floodprone communities and producing Flood Hazard Boundary Maps (FHBMs) for identified communities. (The FIA was originally under the Department of Housing and Urban Development (HUD) and is now part of FEMA.) The early FHBMs were intended to be temporary maps, prepared quickly under a Congressional deadline to delineate floodplain boundaries in all floodprone communities. More than 17,000 FHBMs were produced. While these maps incorporated information available from maps prepared by other federal agencies, the FHBMs showed only the approximate boundaries of floodprone areas within communities. For many communities, however, these maps were the only source of floodplain information available for a decade or more. Nevertheless, since the FHBMs depicted only approximate floodplain boundaries, they provided many communities with only a limited basis for floodplain management.

At the same time as the temporary FHBMs were being prepared, the FIA entered into cooperative efforts with other federal agencies and into contracts with private engineering firms to: 1) develop methodologies suitable for preparing more detailed maps (e.g., "step backwater models," surge models, and wave height models); 2) to conduct Flood Insurance Studies (FISs) based on these methodologies; and 3) to prepare detailed floodplain maps (Flood Insurance Rate Maps (FIRMs)) that would be more suitable for floodplain management and flood insurance purposes.

As of September 1990, more than 12,000 new flood risk studies had been initiated by the FIA and over 1,700 restudies undertaken at a cost of nearly $900 million as shown in Table 6-3. Figure 6-1 shows the number of new study and restudy initiations by fiscal year. The FIA spends about $36 million annually to keep published flood risk information updated and current, and to provide detailed flood risk data where none existed before. Of this amount, about $4 million is spent annually to distribute about seven million maps to states, communities, lenders, agents, banks, consultants, and others.

The National Flood Insurance Act authorized the FIA to use the technical expertise of federal and state agencies and private firms to complete Flood Insurance Studies. In addition to contracting with numerous private firms, FEMA has utilized the resources of the Corps of Engineers, USGS, SCS, TVA, NOAA, the Bureau of Reclamation (BOR), the Delaware River Basin Commission, and the Susquehanna River Basin Commission on a reimbursable basis to perform this work.

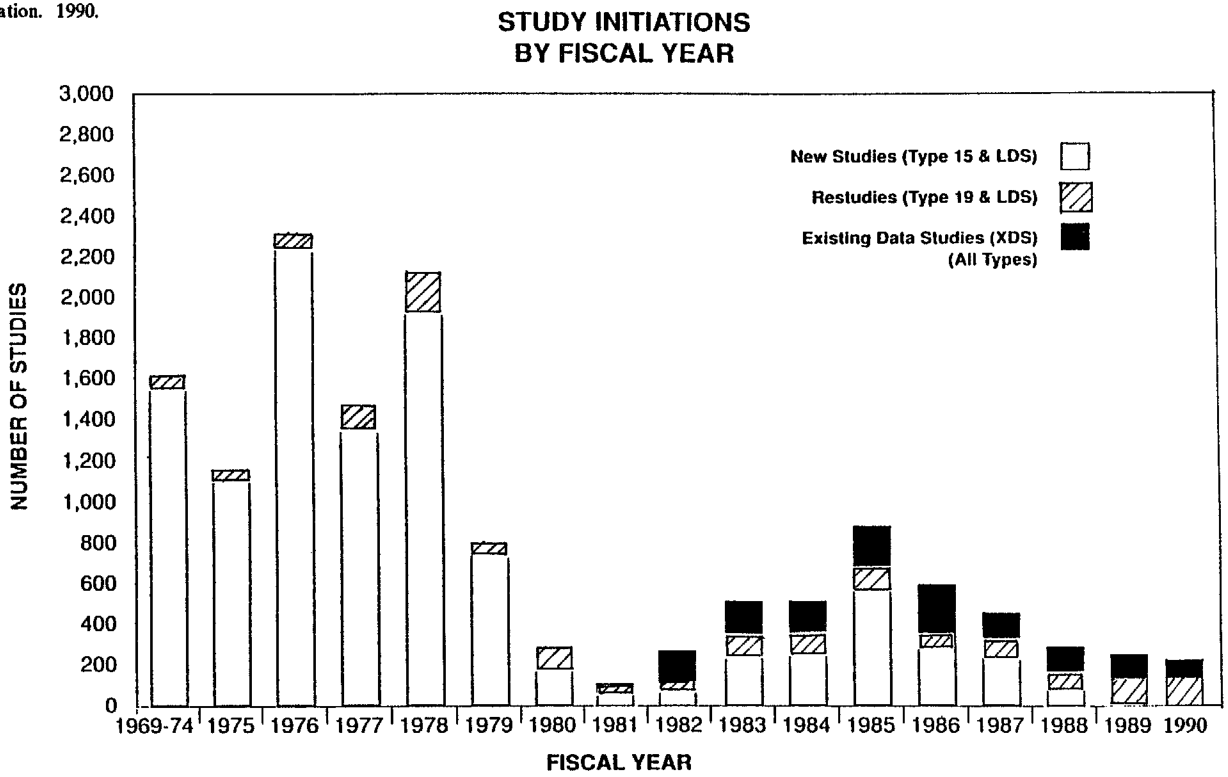
For the period 1969-1974, Flood Insurance Studies were carried out almost exclusively by federal agencies. During 1975-1979, studies were conducted by both federal agencies and private engineering firms, with the percentage performed by private firms increasing until 1979. Study initiations for 1980-1984 were at a minimal level, and the number prepared by federal agencies was about equal to the number prepared by private firms. Table 6-4 shows the breakdown of new study initiations for fiscal years 1984-1990 (Federal Emergency Management Agency, 1991).

Table 6-3. National Flood Insurance Program: Flood Studies and Surveys, Historical Statistics as of September 30, 1990.

NFIP COMMUNITY STATUS:	
Participating Communities in the Emergency Program	280
Participating Communities in the Regular Program	18,023
Nonparticipating (with flood hazard identified)	2,483
Total Communities	20,506
MAP STATUS:	
Emergency Program (Mapped)	251
Regular Program (Mapped)	15,904
Nonparticipating (Mapped)	2,483
Total Mapped	18,638
Regular Program with No Special Flood Hazard Area (Nonfloodprone)	1,788
Emergency Program with Hazard Areas to be Mapped	67
INITIAL RATE STUDY STATUS (TYPE 15):	
Rate Studies and Existing Data Studies Completed	11,653
Rate Studies in Progress at Study Contractors	10
Rate Studies Under Review	404
Existing Data Studies in Progress	79
Total Studies	12,146
RESTUDY STATUS (TYPE 19):	
Restudies and Existing Data Studies Completed	1,132
Restudies in Progress at Study Contractors	237
Restudies Under Review	265
Existing Data Restudies in Progress	92
Total Restudies	1,726
HISTORICAL COSTS:	(Millions)
Total Appropriations	$873.0
Studies	354.8
Restudies	92.2
Technical Review and Cartographics	194.1
Revisions/FHBMs/LOMAs/LMMP	94.8
Printing/Distribution	46.8
Miscellaneous Program Support (Appeals, Special Studies, Projects)	89.7
Digitizing NFIP Maps	0.6

Source: Federal Insurance Administration. Unpublished data. 1991.

Source: Federal Insurance Administration. 1990.



			1969-74	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
TOTAL STUDY INITIATIONS		THIS FY:	1,614	1,156	2,320	1,474	2,123	791	295	90	264	508	507	889	596	453	288	261	243
		CUMULATIVE:	1,614	2,770	5,090	6,564	8,687	9,478	9,773	9,863	10,127	10,635	11,142	12,031	12,627	13,080	13,368	13,629	13,872
NEW STUDY INITIATIONS	□	THIS FY:	1,556	1,142	2,260	1,360	1,935	749	199	59	77	268	278	591	297	258	92	7	6
		CUMULATIVE:	1,556	2,698	4,958	6,318	8,253	9,002	9,201	9,260	9,337	9,605	9,883	10,474	10,771	11,029	11,121	11,128	11,128
	■	THIS FY:	0	0	0	0	0	0	0	11	158	167	129	149	174	90	59	49	32
		CUMULATIVE:	0	0	0	0	0	0	0	11	169	336	465	614	788	878	937	986	1,018
	TOTAL	THIS FY:	1,556	1,142	2,260	1,360	1,935	749	199	70	235	435	407	740	471	348	151	56	32
		CUMULATIVE:	1,556	2,698	4,958	6,318	8,253	9,002	9,021	9,271	9,506	9,941	10,348	11,088	11,559	11,907	12,058	12,114	12,146
RESTUDY INITIATIONS	▨	THIS FY:	58	14	60	114	188	42	96	20	29	73	98	114	53	50	56	145	167
		CUMULATIVE:	58	72	132	246	434	476	572	592	621	694	792	906	959	1,009	1,065	1,210	1,337
	■	THIS FY:	0	0	0	0	0	0	0	0	0	0	2	35	72	55	81	60	44
		CUMULATIVE:	0	0	0	0	0	0	0	0	0	0	2	37	109	164	245	305	349
	TOTAL	THIS FY:	58	14	60	114	188	42	96	20	29	73	100	149	125	105	137	205	211
		CUMULATIVE:	58	72	132	246	434	476	572	592	621	694	794	943	1,068	1,173	1,310	1,515	1,726

Figure 6-1: National Flood Insurance Program: Study Initiations by Fiscal Year.

Table 6-4. Breakdown of Flood Insurance Studies and Restudies for Fiscal Years 1984-1990.

FY	ARCHITECT-ENGINEER INITIATIONS	FEDERAL AGENCY INITIATIONS	TOTAL INITIATIONS
1984	312	195	507
1985	263	626	289
1986	394	202	596
1987	412	41	453
1988	227	61	288
1989	192	69	261
1990	118	125	243

Source: Federal Insurance Administration. 1991.

Corps of Engineers Mapping

A great deal of effort on the part of the Corps of Engineers' Flood Plain Management Services (FPMS) Program has been in support of the NFIP. Much of the data generated for the Corps' flood plain information reports were used to provide flood insurance mapping for FEMA. The Corps phased out its flood plain information report program to avoid duplicating the effort of Flood Insurance Studies. Reimbursable work by the Corps to prepare FISs represents a major floodplain management effort. By 1985, the Corps' FPMS Program had administered $117 million to prepare 2,600 FISs for the NFIP (U.S. Army Corps of Engineers, 1988). Table 6-5 shows floodplain mapping studies by the Corps of Engineers from 1969 to 1988.

Soil Conservation Service Mapping

The Soil Conservation Service started its first Flood Insurance Study for the Federal Insurance Administration in 1969 on a reimbursable basis. Through 1987, the SCS had begun 496 studies and completed 477 for the FIA. Under Section 6 of the Watershed Protection and Flood Prevention Act of 1954, the SCS began working on Flood Plain Management Studies in 1970. These studies are funded by the SCS, sometimes with financial participation by local sponsors, and are performed to meet the requirements of the NFIP. Through 1987, the SCS had initiated 491 Flood Plain Management Studies and completed 409. Table 6-6 gives an annual tabulation of study completions for both types of studies. Flood Plain Management Studies and FISs include floodplain delineations and flood profiles (U.S. Department of Agriculture, 1979; von Wolffradt, 1987).

Table 6-5. Floodplain Mapping Studies by the Corps of Engineers, 1969-1988.

YEAR	FLOOD INSURANCE STUDIES	FLOODPLAIN INFORMATION STUDIES	SPECIAL FLOOD HAZARD INFORMATION STUDIES
1969	20	125	40
1970	80	125	50
1971	185	150	50
1972	130	200	50
1973	160	225	60
1974	110	225	60
1975	260	250	75
1976	430	250	75
1977	310	0	85
1978	200		95
1979	260		85
1980	20		80
1981	15		75
1982	70		25
1983	170		15
1984	140		20
1985	95		25
1986	80		30
1987	130		45
1988	25		55
TOTAL	2890	1550	1095

Source: U.S. Army Corps of Engineers, 1989.

Tennessee Valley Authority Mapping

As a result of establishment of the NFIP in 1968, the Tennessee Valley Authority curtailed its program for publishing flood hazard information reports in favor of flood insurance studies prepared by the FIA. Since the early 1970s and through 1988, 322 flood insurance studies have been completed for communities in the Tennessee River watershed. Most of these studies have been carried out for the FIA by the TVA under a contractual arrangement.

A program as large as the NFIP mapping effort has not been without controversy. Most early concerns were related to disagreements over the level of detail, and therefore cost, that was appropriate in such an extensive effort. Most concerns during the past ten years have been related to differences between the mapping needs of floodplain managers and the needs of flood insurance insurers and agents. These concerns and other aspects of the NFIP mapping program are described in Chapter 11 in the section on Floodplain Regulations.

Table 6-6. Floodplain Mapping Studies by the Soil Conservation Service.

FISCAL YEAR	FLOODPLAIN MGMT. STUDIES START	FLOODPLAIN MGMT. STUDIES COMPLETE	FLOOD INSURANCE STUDIES START	FLOOD INSURANCE STUDIES COMPLETE
1969	0	0	1	0
1970	2	0	16	3
1971	4	2	61	3
1972	21	1	39	61
1973	27	5	24	23
1974	61	12	14	8
1975	35	20	37	8
1976	37	48	86	21
1977	12	32	52	37
1978	15	33	41	40
1979	20	37	64	54
1980	28	31	5	81
1981	22	25	0	42
1982	56	19	13	24
1983	33	27	13	19
1984	56	36	13	9
1985	29	40	0	3
1986	18	29	8	15
1987	19	28	9	15
TOTAL	491	409	496	477

Source: von Wolffradt, Donald B. Soil Conservation Service, U.S. Department of Agriculture. Personal correspondence, 1987.

U.S. Geological Survey Mapping

The U.S. Geological Survey has been preparing maps of floodplains for the NFIP since 1968. Table 6-7 shows that the USGS has initiated approximately 581 flood insurance studies since fiscal year 1985. In 1985, the USGS formalized limited-detail study methods for application to flood insurance studies (Cobb, 1985). Limited-detail methods identify only the profile and boundaries for the one percent chance flood, and do not identify a floodway. In cooperation with the NFIP, the USGS, from March through September 1984, evaluated streams in 2,349 communities for the application of limited-detail study methods.

Table 6-7. Studies for Flood Insurance Purposes by the U.S. Geological Survey Since 1985.

FISCAL YEAR	FLOOD INSURANCE STUDY STARTS
1985	482 (a)
1986	13
1987	10 (b)
1988	28 (b)
1989	13 (b)
1990	18 (b)
1991	17 (b)

(a) 471 of these were limited-detail studies.
(b) Approximate number of studies started.

Source: Cobb, Ernest D. U.S. Geological Survey. 1991.

STATE AND COMMUNITY FLOODPLAIN MAPPING

A 1988 survey (Association of State Floodplain Managers, 1988) showed that 23 states fund and prepare their own floodplain maps to complement the NFIP program. Reasons for state-initiated mapping included:

- 16 states map areas to provide greater detail, better scale, or other map improvements.
- 12 states map areas to reflect changes in development or hydrology.
- Six states map areas for flood control planning purposes where mapping must be of greater detail and go beyond corporate limits.
- Three states map unique flood hazards or special natural values such as wetlands.

As examples of state and community floodplain mapping: Colorado has shared costs with FEMA to have flood studies transposed on topographic maps with two-foot contour intervals at a scale of 1" = 200'. The State of Alaska has a program to map "geophysical hazard areas." Minnesota shares costs with communities that request updated maps. The communities provide surveying and topographic mapping and the state provides the hydrologic and hydraulic computations and delineations.

A few states have mapped landslide hazards, generally in limited areas where the risk is extremely high or where there is rapid urbanization. Some states have adopted regulations for geologic hazards, but only California has followed through with standards and codes (National Research Council, 1985). California has also legislated the mapping of landslide hazards by the State Geologist and, beginning in 1984, budgeted about $300,000 annually for this purpose (Kockleman, 1986). The Utah Legislature has also appropriated funds for state-wide mapping of debris-flow hazards (Christenson, 1986).

As with the states, communities have generally not been involved in floodplain mapping, although there are numerous exceptions. Communities have become more involved, particularly in the past few years, as federal mapping (or remapping) funds have decreased. Beginning in 1985, local financial participation in mapping, through joint funding or other contributions, has improved a community's priority rating for receiving federal funds for remapping.

Also, several large western communities have begun mapping flood hazards on their own in response to their unique floodplain management situations, and in accordance with comprehensive local programs requiring more specialized mapping. These community mapping efforts consider future condition flooding, watershed management, erosion, and/or larger flood peaks than those used by the FIA for flood insurance purposes.

In addition, private consultants frequently conduct hydrology or drainage studies for subdivisions and other developments. Prior to the 1970s, such studies were not required as frequently as they are now because of the lack of sophisticated analytical capabilities as exist today, and the lack of ability, on the part of most communities, to review such studies. These studies form the basis for many amendments and revisions to original FIRMs.

UNDERSTANDING AND MAPPING OF WETLANDS

Significant improvements in wetlands mapping have also occurred. In the mid-1960s there was limited appreciation of the role of inland and coastal wetlands in providing a variety of useful and vital functions. Beginning in the 1970s, there has been significant improvement in both the scientific and public awareness of wetland values and, as a result, much effort has been put into the mapping of wetlands. Many states have developed their own mapping programs, and it is at the state level that much of the mapping of wetlands has occurred. The mapped information is not entirely uniform because of different approaches (based on soils or vegetative criteria, for example) used to define wetlands.

National Wetlands Inventory Project

Wetlands mapping on a national basis is being performed by the U.S. Fish and Wildlife Service (FWS). This program, known as the National Wetlands Inventory Project (NWI) was established in 1974 to provide scientific information on the extent and characteristics of the Nation's wetlands. As part of the program, two types of information are being prepared: 1) detailed maps; and 2) status and trends reports. Detailed wetland maps are needed for impact assessment of site-specific projects, and are used by local, state and federal agencies and by private organizations for many purposes, including the development of comprehensive resource management plans, environmental impact assessments, oil/chemical spill contingency plans, natural resource inventories, and wildlife surveys. Wetland maps are also used to support facility siting and permit review decisions. National estimates of the current status and trends (in terms of losses and gains) of wetlands are needed to provide improved information for reviewing the effectiveness of existing federal programs and policies, for identifying national or regional problems, and for general public awareness (Tiner, 1984).

Two series of wetland maps are being prepared: 1) small-scale (1:100,000 or 1:250,000); and 2) large-scale (1:24,000). The 1:100,000 scale maps cover approximately 1,700 square miles and cover the same area as 32 1:24,000 scale maps. The 1:100,000 scale maps are used chiefly for watershed and regional planning and are now being produced in only limited areas where map users provide funding for map preparation. The primary map product is the large-scale map showing the location, shape, and characteristics of wetlands and deepwater habitats transposed on a USGS base map. Wetlands are classified according to the FWS wetland classification system, and the detailed maps may be used for site-specific project evaluation.

Seven major steps are involved in the preparation of NWI maps:

1) preliminary field investigations,
2) interpretation of high-altitude photographs,
3) review of existing wetlands information,
4) quality control of interpreted photos,
5) draft map production,
6) interagency review of draft maps, and
7) final map production.

An evaluation of NWI maps by the University of Massachusetts determined that the maps had accuracies above 95 percent (Tiner, 1987).

Through mid-1990, wetland mapping had been completed for eleven states: Arizona, Connecticut, Delaware, Hawaii, Maryland, Massachusetts, New Jersey, Pennsylvania, Rhode Island, Vermont, and Virginia. Mapping of West Virginia was almost completed. The NWI has finished mapping for 65 percent of the conterminous 48 states and 20 percent of Alaska (Gooklin, 1990).

Functional Values of Wetlands

Numerous attempts have been made to develop methodologies to assess the functional values of wetlands. In 1981, over 40 methods for evaluation of wetlands existed. In 1979, the Water Resources Council examined the state-of-the-art in wetlands evaluation as part of a series of workshops on "Emerging Issues in Wetland/Floodplain Management" (Balco, 1981). An analysis of 20 existing methodologies was carried out by the Corps' Waterways Experiment Station (Lonard, 1981).

The two basic kinds of wetlands evaluation involve:

- Determining the relative ecological value of the wetland (i.e., the quality of the wetland as compared with other wetland sites, or its suitability for supporting wildlife), sometimes referred to as "scaling and weighing approaches"; and
- Comparing natural wetlands to human ecosystems and reducing wetland values to monetary terms (i.e., comparison of the ecological value of the habitat against the economic value of some proposed activity that would destroy or modify it), sometimes referred to as "common denominator approaches."

However, " . . . there is no universal agreement about which [approach to valuation of wetlands] is preferable. In part, the choice depends on the circumstances" (Mitsch, 1986).

Much of the impetus for development of the various evaluation methodologies stems from federal regulatory and water resources planning requirements. Agencies that have played a major role include the Corps of Engineers, SCS, FHWA, and the FWS. In addition, other methodologies have been developed for use by states in their wetland regulatory programs. Many of these methodologies borrow from, or integrate, concepts of the approaches developed by the federal agencies.

The natural and functional values of wetlands are described in greater detail in Chapter 14.

Wetland Restoration and Creation

Wetland restoration, creation or enhancement efforts have received a great deal of attention in the last several years and many projects have been undertaken. The success of these projects is difficult to determine, however, for several reasons, including lack of specific project goals, limited monitoring, and the short time that has elapsed since most projects were completed.

While it is impossible to fully duplicate natural systems, new or restored wetlands with many of the characteristics of natural systems can be established in some circumstances. It may not be possible, however, to create all wetland types or functions. Particularly during the early years of wetland creation projects, the wetlands may have very different functions than the wetland systems they are intended to replace (Kusler, 1986).

In 1986, the EPA adopted a Wetlands Research Plan designed to: 1) improve methods of creating, restoring, and enhancing wetlands and wetland functions; 2) to provide guidance for the design of effective projects; and 3) develop methods for evaluating the potential and actual success of projects. In 1989, the EPA released its first major publication resulting from research under the Wetlands Research Plan. The report, *Wetland Creation and Restoration: The Status of the Science* (Kusler and Kentula, 1990), found that:

- Practical experience and the available science base on [wetland] restoration and creation are limited for most [wetland] types and varies regionally.
- Most wetland restoration and creation projects do not have specified goals, complicating efforts to evaluate "success."
- Monitoring of wetland restoration and creation projects has been uncommon.
- Restoration or creation of a wetland that "totally duplicates" a naturally occurring wetland is impossible; however, some systems may be approximated and individual wetland functions may be restored or created.
- Partial project failures are common.
- Success varies with the type of wetland and target functions, including the requirements of target species.

- The ability to restore or create particular wetland functions varies by function.
- Long-term success may be quite different from short term success.
- Long-term success depends upon the ability to assess, re-create, and manipulate hydrology.
- Success often depends upon the long-term ability to manage, protect, and manipulate wetlands and adjacent buffer areas.
- Success depends upon expertise in project design and upon careful project supervision.
- "Cook book" approaches for wetland restoration or creation will likely be only partially successful.

Wetland restoration/enhancement and creation, along with a related management technique known as wetland mitigation banking, are described in Chapter 14.

UNDERSTANDING OF OTHER NATURAL AND CULTURAL RESOURCES

Rivers, streams, coastlines, and adjacent floodprone land contain some of the Nation's most important natural resources. Many communities were established along the Nation's water bodies, and some of the oldest developments and most significant cultural resources are found in and near floodplains. Significant advances have been made with regard to the overall understanding of natural resource functions and the importance of maintaining the Nation's natural and cultural heritage. Various information and data sources have been developed which have aided this understanding. These include sources of data and information on: natural and/or cultural resources (including resource quality and quantity); biodiversity; endangered and threatened species; unique resources; and environmental and cultural resource locations, sites and networks.

Increasingly sophisticated information on the above subjects is being assembled and presented in a variety of forms and formats. Perhaps the greatest progress has occurred in developing information management systems. Many information sources now use computer-based data storage and retrieval systems to manage large and dynamic data bases that include both federal- and state-derived information. Many systems are linked together and can be very useful in assessing resource information for a variety of purposes and needs. The systems can be used to assess the type and extent of the natural and cultural resources of the Nation's floodplains and can aid in determining the value of those resources. Other data systems can be reduced to information on a particular stream or stream segment. The following examples, which were principally reported in a U.S. Environmental Protection Agency study, demonstrate the magnitude and breadth of current data and information systems (U.S. Environmental Protection Agency, 1990).

- U.S. ENVIRONMENTAL PROTECTION AGENCY: The EPA maintains several dozen water quality-related data bases containing state, EPA, and other federal agency data. Most of this information is linked together for access using the stream reach (segment) coding structure in the EPA's STORET data base. The EPA data bases, individually and through linkages that have been and are being developed, can be very useful in assessing water quality. The EPA's BIOS data base contains descriptions of the distribution, abundance, and condition of aquatic organisms and their habitat at sampled sites.

- U.S. DEPARTMENT OF THE INTERIOR: The Department of the Interior (DOI) also has extensive computer-based systems for natural resources data, including the Water Data Storage and Retrieval System (WATSTORE) and the National Water Data Exchange (NAWDEX). Both of these systems are managed by the U.S. Geological Survey and compile water data being collected from tens of thousands of sites throughout the Nation. The USGS also manages land-use data (40 different types) for the entire Nation based on LANDSAT satellite imagery collected primarily in the mid-1970s. The National Wetlands Inventory (NWI) being carried out by the U.S. Fish and Wildlife Service (FWS) and includes development of a computerized mapping scheme for the entire country. The NWI contains vegetation data for 3,500 wetlands species, ecological community types, and classification according to wetlands types. The FWS prepares an annual list of all National Wildlife Refuges and other lands under its control. The FWS also maintains a national survey of fishing, hunting, and wildlife-associated recreation.

  The Nationwide Rivers Inventory developed by the National Park Service (NPS) lists over 1,500 river segments (approximately 62,000 miles) thought to have sufficient natural or cultural attributes to qualify for consideration for inclusion in the Nation's Wild and Scenic Rivers System. The NPS National Natural Landmarks Program provides a register of significant natural areas illustrating the diversity of the natural heritage of the United States. Maps of these areas have been prepared along with information on their ecological and geological characteristics. The NPS also operates the National Register of Historic Places which catalogs thousands of cultural and historic sites throughout the country.

  The DOI's Endangered Species Information System contains information on species listed under the Federal Endangered Species Act, including their status as endangered or threatened, and factors contributing to their present status. The Endangered Species Information System provides information on the habitat types associated with various species, current and past species location by county and state, watersheds/subunits where the species are found, and counties and states with designated critical habitat.

- THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION: The U.S. Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) is the Nation's principal marine science agency. NOAA produces and maintains natural resources data primarily through the National Ocean Service (NOS) and the National Marine Fisheries Service (NMFS). The NOS compiles data and conducts assessments relating to issues of coastal marine and estuarine environmental quality. Through its National Status and Trends (NS&T) Program, the NOS monitors the spatial distributions, temporal trends, and biological effects of over 70 contaminants in sediments, mollusks, and fish at over 300 coastal sites throughout the United States. The fish monitoring component of the NS&T Program (the Benthic Surveillance Project) is conducted in partnership with the NMFS. The NOS also maintains a comprehensive data base on the health and status of over 100 U.S. estuaries through its National Estuarine Inventory (NEI). As part of its Coastal Zone Management Program activities, NOS has developed a National Coastal

Wetlands data base, containing acreage estimates for 10 wetland habitat types encompassing over 27 million acres of the contiguous United States. Through its Estuarine Living Marine Resources (ELMR) Program, the NOS is compiling a comprehensive data base on the spatial and temporal distribution and relative abundance of approximately 150 fish and invertebrate species in over 100 U.S. coastal estuaries. The NOS's National Coastal Pollutant Discharge Inventory (NCPDI) contains estimates for all point, nonpoint and upstream sources of pollutants discharged into coastal waters of the contiguous United States. The NMFS administers comprehensive data bases with information on commercial and recreational fisheries of the United States and foreign catches in the U.S. Exclusive Economic Zone. Through Regional Fisheries Management Councils, data bases are compiled for the NMFS pertaining to the conservation and management of living marine resources in the United States.

- U.S. DEPARTMENT OF AGRICULTURE: Within the Department of Agriculture, the Soil Conservation Service maintains a National Resources Inventory which is a national survey based on 160-acre units. Each unit contains data on land use, conservation practices, soil type, and erosion characteristics. The U.S. Forest Service has information on land areas within the National Forest System including designated wilderness areas, primitive areas, recreation areas, and wildlife preserves.

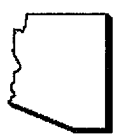
- STATE AND PRIVATE DATA SOURCES: State and private data sources include state natural heritage programs that identify elements essential to preservation of biological diversity, and provide information on the existence and location of rare and endangered plants and animals as well as inventories of unique plant communities and aquatic systems. Over half of the states have developed such programs in cooperation with The Nature Conservancy. The Nature Conservancy also maintains a listing, by state, of waters containing key elements of biological diversity. This listing has been developed with assistance from the state heritage programs. American Rivers has compiled the state lists used to set priorities for river conservation and has incorporated those lists into a report and computerized data base. The *Outstanding Rivers List* contains 15,000 entries, totaling some 300,000 river miles, and documents the great diversity of government and citizen interest in rivers. The Cornell Laboratory of Ornithology provides a census, along with historical data, of 200 bird species by country. The Lawrence Berkeley Laboratory maintains a collection of socioeconomic, environmental, demographic, and health-related data bases covering geographic regions, and these data bases are updated annually.

REMOTE SENSING TECHNIQUES

Much progress has been made in the past twenty years to increase the availability and analysis of high altitude photography, satellite imagery, and other forms of remote sensing. Systematic comparisons of images from different time periods can provide information on changes in land use, aid in the assessment of many natural values, and point out areas where future flood damages may occur. After land uses and natural values are calculated for an area, much of the analysis may be automated. These techniques have so far been applied on a limited basis in relatively small areas of the Nation's floodplains.

Numerous examples of the use of aerial photography and satellite imagery for monitoring land use can be cited, including a 1973 study of South Dade County, Florida where photos from 1963 and 1971 were used in conjunction with 1970 census data to evaluate land-use trends (U.S. Geological Survey, 1973). The use of LANDSAT data to determine land use has been tested. Researchers have determined that LANDSAT can be successful in monitoring basic land use under the USGS classification system, and has the advantage that the data are periodically available to update land-use information (Still, 1985). Efforts are underway to make these technologies available to such users as communities and practicing engineers and hydrologists. For example, NASA's Earth Resources Laboratory has been working to develop software to make satellite and aerial imagery available to all users at a reasonable cost (Howard, 1985).

Many communities routinely use aerial photography from two flight dates to update their tax assessment files and to identify construction for which building permits may not have been obtained.



At least one Arizona community uses periodic aerial observations to look for floodplain violations. Satellite imagery also is used in Arizona for ground-water management purposes to determine the amount of irrigated land and the types of crops being grown (Bond, 1988). This technology could be adapted to floodplain management, although the costs at the present time dictate that only federal or state agencies, and a very few large cities, could afford such monitoring.

Aerial photography combined with floodplain maps has been used in some communities to count the number of structures within selected floodplains (Williams, 1987). Other communities have used or are anticipating using low level aerial photography following floods to assist with determinations of the extent of flooding and with damage assessments (L.R. Johnston Associates, 1987).

Remote sensing techniques, however, are currently being applied in only limited ways for floodplain management. In the future, higher resolution high altitude photography and other forms of remote sensing should permit greater accuracy in identifying floodplain activities, and enable the inventory and mapping of changes in floodplain use. The use of aerial, and particularly satellite, imagery and other forms of remote sensing may not grow rapidly until more automated procedures for processing data are available. As digital mapping becomes more widespread, the ease of monitoring floodplain activities through remote sensing is likely to increase, and the cost should decrease.

GEOGRAPHIC INFORMATION SYSTEMS

The substantial improvement in computer systems during the last two decades has made it much easier to apply computer technology to the problems of storing, manipulating, and analyzing large volumes of spatial data. Today, many organizations make routine use of what are called geographic information systems for a wide variety of purposes, including natural hazards assessment and natural resource management. A Geographic Information System (GIS) is a computerized system designed to collect, manage, and analyze large volumes of spatially referenced and associated attribute data (Guptill, 1988). GISs may comprise quite sophisticated computer software, but all systems contain the following major components.

1) A data input subsystem that collects and/or processes spacial data derived from existing maps, remote sensors, etc.

2) A data storage and retrieval subsystem that organizes the spatial data in a form that permits it to be quickly retrieved by the user for subsequent analysis, and permits rapid and accurate updates and corrections to the spacial database.

3) A data manipulation and analysis subsystem that performs a variety of tasks such as changing the form of the data through user-defined aggregation rules, or producing estimates of parameters and constraints for various space-time optimization or simulation models.

4) A data-reporting subsystem that is capable of displaying all or part of the original database as well as manipulated data and the output from spatial models in tabular or map form. The creation of these map displays involves what is called digital or computer cartography. This is an area that represents a considerable conceptual extension of traditional cartographic approaches as well as a substantial change in the tools used to create the cartographic displays.

The above definition of a Geographic Information System excludes a number of software systems that meet only part of the stated criteria. For example, digitizing systems that concentrate on the problem of data capture from map documents and that provide minimal data storage/retrieval capabilities and only "quick-look" graphics are clearly not geographic information systems. Neither are most remote sensing and image processing systems. Similarly, thematic mapping packages that concentrate on the production of complex computer maps do not qualify (Marble, 1987).

Many federal, state and local government agencies, as well as private organizations, are now beginning to develop or use some type of GIS. The need for larger amounts of information on smaller scale projects makes the GIS a useful tool for the planning and management of all types of natural hazards and resources. The GIS, however, has not yet become a widely used tool, in large part because only a limited amount of needed information has yet been entered into geographic information systems. Another constraint is that the different systems now in use are not always compatible. Standards committees set up by professional organizations and government agencies, however, may help to greatly reduce compatibility problems in the near future. In 1988, a "Proposed Standard for Digital Cartographic Data" was published as a special edition of *The American Cartographer* (Vol 15, No. 1, January 1988). The proposed standard consists of four major components: definitions and references, spatial data transfer, digital cartographic data quality, and cartographic features. This standard is an attempt to meet the recognized requirement for easy transfer of spatial data from one spatial data handling system to another, and with both systems possibly residing on computer hardware and operating system software of different makes (Guptill, 1988).

Once information is available in a compatible format, GIS technology holds great promise for allowing planners and managers to easily identify and update the information needed to improve their decision-making processes. GIS systems will be able to combine natural resources data with data on man-made features and generate comprehensive maps and data bases of geographic areas of concern. GIS-generated maps are expected to be easily manipulated and updated at low cost, thereby overcoming one of the major obstacles in floodplain management today. Thematic data regarding land parcel boundaries, land ownership, and political boundaries are critical to the use of GISs for floodplain management purposes. The initial cost of digitizing this information for input into a GIS, however, can be significant.

Geographic information systems were available during the 1960s and early 1970s, but for very specialized and limited applications. Most of the early GISs were developed and supported by universities and employed a grid-based mapping technique. Maps generated by these early systems were composed of small squares (grids) and were of limited accuracy. Most current systems rely on vector graphics (as opposed to grid mapping) for increased accuracy and resolution. As computer hardware and software systems improve, grid data may again come into widespread use because they can offer greater resolution for continuously variable features such as topography.

As with so many other recent advances, new computers have made possible remarkable advances in GIS technology. While most GISs still require at least a mini-computer for efficient operation, some systems have recently been made available for use on microcomputers. Over the next several years, even small cities should be able to develop, maintain, and update comprehensive GISs. A few more years may be required to bring the utility of the most powerful current GIS to the local community, because of the very large data storage and retrieval capabilities that are needed, and the complexity of the system.

Much of the recent advancement in geographic information systems has occurred within the private sector. Several companies have invested in developing proprietary GISs in anticipation of selling these systems to a potentially vast market. While a few private systems currently dominate the GIS market, many more systems hold smaller shares of the market and new systems are still being produced.

GIS technology has great potential for developing integrated mapping that can provide for overlays of different types of natural and cultural resources. As Census Bureau data and geographical data developed from LANDSAT images become more readily available, the use of GISs should expand greatly. GIS availability should promote greater comprehensive planning and monitoring of changing conditions.

An example of a recent GIS system being used for natural resources management purposes, is provided by the Henderson County, North Carolina Soil and Water Conservation District. This is one of the first conservation districts in the Nation to install a microcomputer-based geographic information system to provide better interpretative soils information. The county's published soil survey has been digitized and stored in the system, and the computer system can capture, store, analyze and retrieve soils maps and other geographic data. A major portion of the funding for the demonstration project was provided by the TVA, supplemented by funds from the Soil Conservation Service (SCS) and the Henderson County Commissioners (National Association of Conservation Districts, 1987).

The National Cartographic Information Center has digitized land-use and land cover information from NASA high-altitude aerial photographs and National High-Altitude Photography (NHAP) program photographs, usually on 1:250,000-scale base maps. For most urban and industrial uses, the minimum size polygon used for digitizing is four hectares (ha), equal to a square with 200 meter sides. For other uses, the minimum polygon size is 16 ha. There are seven categories of urban or built-up land

and 31 categories of agricultural, forest and other nonurbanized land use. National coverage is planned (U.S. Geological Survey, 1986).

The Federal Emergency Management Agency has initiated pilot projects to develop Flood Insurance Rate Maps on a GIS-based mapping system. In 1987, FEMA conducted a survey of floodplain managers in an initial attempt to determine potential users for digital data from FIRMs. The survey included public officials, private organizations and citizens. "Of those responding to this survey, 97 percent were found to have some type of computer capability, including 25 percent possessing micro and mainframe computer capabilities. Eighty-five percent of those responding stated that they would use digital FIRM data if it were free, 45 percent stated they would use digital FIRM data if it were available at a reasonable cost, and 35 percent indicated that they would use digital FIRM data regardless of cost." Based on the survey, FEMA concluded that "there is both a strong interest in digital FIRM data and that there exists, in both the public and private sectors, the needs and resources to utilize digital FIRM data" (Federal Insurance Administration, 1987).

FEMA is developing a standard for digital FIRMs in public domain format consistent with USGS Line Graph (DLG) standards. FEMA has also committed to a program to digitize FIRMS for at least 340 counties in the Consolidated Metropolitan Statistical Areas with the greatest amount of property at risk to flooding. This six-year program will provide digital FIRMs covering more than 75 percent of the Nation's property-at-risk and will be initiated in FY 1991 (Federal Emergency Management Agency, 1989).

SUMMARY AND CONCLUSIONS

Knowledge and understanding of the processes that create floodplains and of the consequences of human interaction with floodplains are necessary for effective floodplain management. Both long-term and short-term climatic data are important in assessing flooding probabilities. Many floodplain management efforts have been predicated on the assumption of constant climate conditions, an assumption that may or may not be valid. Recent studies illustrate that traditional averages may not be adequate to describe the consequences of global climate changes. The lack of sufficient long-term data leaves many uncertainties in predicting the rate of future climate changes. The rate of sea level rise in some areas is expected to continue over the next century and could exacerbate coastal and estuarine flooding.

The National Weather Service is the primary agency for collection of climatic data to aid in flood forecasting. The NWS collects data from about 230 stations in the United States and also reports data collected by over 1300 ships. The U.S. Geological Survey operates over 93 percent of the Nation's stream gaging network and publishes data on peak flood flows, as well as water quality in the United States. These data are essential to understanding the hydrology and hydraulics of flooding and for delineating floodplain boundaries. Systematic records are subjected to analyses to determine flood frequencies and magnitudes. The USGS, the Corps of Engineers, Soil Conservation Service and other agencies have developed hydraulic models used for calculating the flood profile elevations needed for floodplain mapping. The USGS initiated special flood studies in 1902 with a report on the Passaic River flood in northeastern New Jersey.

The Tennessee Valley Authority, Corps of Engineers, Soil Conservation Service and others have joined in producing floodplain information in response to specific Congressional authorization. Enactment of the National Flood Insurance Act in 1968 resulted in establishing the "100-year flood" as the base flood for determining risk and also led to a systematic effort to map the Nation's floodplains. The technical expertise of federal and state agencies and private firms has been utilized on a continuing basis.

Beginning in about 1970, federal and state agencies became more aware of the value of wetlands. Floodplains contain a significant amount of the Nation's wetlands, and methodologies are being improved to assess the functional values of wetlands.

Extensive progress has also been made in the development of remote sensing techniques that have resulted in increased accuracy for the identification of floodplains and flood-related flows. The use of improved data bases combined with advances in computer systems has led to geographic information systems that provide useful information directly to national and local floodplain managers. Projects are being developed to integrate floodplain maps with the cartographic data base of the USGS.

Major progress has been made in both understanding and measuring many of the basic processes and values important for floodplain management. In some cases, entirely new techniques, such as satellite remote sensing, have been developed to aid understanding or measurement. In other cases, techniques and processes long in existence, such as hydrological models, have been refined or come into widespread use. Mapping of floodprone areas represents perhaps the single greatest increase in our knowledge of flood hazards.

Clearly though, much remains to be done. In many instances, the ability to accurately measure status and trends has lagged behind advances in understanding the processes involved. Factors contributing to this disparity include lack of consistent and uniform definitions, the expense of data collection, absence of a national level leadership, and absence of specific responsibilities for collecting, assembling, and evaluating information. In some cases, substantial information is available in government offices and other locations, but has not been assembled into useful formats.

CHAPTER 7:

THE MANAGEMENT FRAMEWORK

> *... [T]he relative role of the Federal government in national floodplain management is declining as local, but especially state, governments have begun to develop experience and effective programs.*
>
> *A Unified National Program for Floodplain Management*, 1986

Floodplain management is necessarily carried out within an established legislative, judicial and administrative framework. The extent and manner to which floodplain management activities are conducted at each level of government is highly dependent on authorizing legislation, the agencies assigned responsibility for carrying out legislative mandates, and the availability of funds to pursue those mandates. Success in achieving stated goals may also depend on the extent to which programs and authorities are coordinated (or fragmented) at and between each level of government. There are examples of individuals and agencies achieving significant floodplain management accomplishments through initiative and creative action even though they may have lacked all of the prerequisite legal and administrative tools. By and large, however, effective action at any level of government is not achieved without a clear and adequate management framework.

Since House Document No. 465, *A Unified National Program for Managing Flood Losses*, was released in 1966, numerous changes have occurred in the management context for floodplain management. Some of these changes — notably establishment of the National Flood Insurance Program (NFIP) — were the direct result of initiatives to implement a recommendation contained in House Document No. 465 or some aspect of the Unified National Program. Many more changes have resulted from a combination of other factors.

This chapter identifies some of the most significant changes that have influenced the management framework for floodplain management. Legislation, executive orders and directives, and interagency actions have all affected significant policy changes and have established, made major modifications to, or eliminated specific programs and agency responsibilities. Changes in the management framework have occurred as new problems have been identified, previously established goals achieved, and additional needs recognized.

The Unified National Program for Floodplain Management envisions integration of the flood loss reduction and natural resources protection aspects of floodplain management. While some integration is evident, these two aspects of floodplain management have generally developed independently. Therefore, changes in the management framework for flood loss reduction and in the management framework for protection of floodplain natural resources are described separately in this chapter.

Implementation of activities authorized under the overall management framework are described in Part IV of the *Assessment Report.*

THE MANAGEMENT FRAMEWORK FOR FLOOD LOSS REDUCTION

The management framework for flood loss reduction does not exist as a separate, easily identifiable set of legislative and policy directives. In many cases flood loss reduction initiatives are included within a broader program effort. In particular, flood loss reduction directives are frequently included as part of broader initiatives in the fields of water resources management, emergency management, environmental protection, and community development and redevelopment. A number of important legislative and administrative actions have helped shape the flood loss reduction aspect of floodplain management over the past 25 years.

THE FEDERAL FRAMEWORK FOR FLOOD LOSS REDUCTION

Figure 7-1 lists the federal agencies with programs directly or indirectly related to flood loss reduction. Several significant changes in agencies and their functions have occurred since the 1960s. Probably the most significant organizational changes were the creation of the Federal Emergency Management Agency (FEMA) by Executive Order in 1979; the transfer of the Federal Insurance Administration (FIA) and the Federal Disaster Assistance Administration (FDAA) from the Department of Housing and Urban Development (HUD) to FEMA; the creation of the U.S. Water Resources Council (WRC) in 1965 (and its subsequent elimination by executive action in 1982); and reorganization of the Bureau of Reclamation (BOR) beginning in 1987.

These organizational changes along with numerous legislative actions had a major impact on the direction of floodplain management over the last 25 years. The major actions that have created the current federal framework for flood loss reduction are described below.

The Water Resources Planning Act of 1965 and the U.S. Water Resources Council

The Water Resources Council was created as part of the Water Resources Planning Act of 1965 (P.L. 89-80). Under Title I of this Act, the WRC was charged with the following mandatory responsibilities (Holmes, 1979):

1) Prepare a national assessment (biennially, or less frequently, if appropriate) of regional water supply and demand.

2) Study the adequacy of regional and river basin plans, and existing and proposed policies and programs.

3) Study the adequacy of administrative and statutory means for coordinating federal agency water resources programs and policies.

4) Make recommendations to the President concerning federal water resources policies and programs.

Federal Floodplain Management and Related Programs by Agency	Department of Agriculture						Department of the Army	Department of Commerce			Department of Energy	Department of Health and Human Services	Department of Housing and Urban Development		Department of the Interior				Department of Transportation				Federal Emergency Management Agency		Small Business Administration	Tennessee Valley Authority	Department of State
	Agriculture Research Service	Agriculture Stabilization and Conservation Service	Economic Research Service	Farmers Home Administration	Forest Service	Soil Conservation Service	Corps of Engineers	National Oceanic and Atmospheric Administration	Economic Development Administration	Bureau of Economic Analysis	Federal Energy Regulatory Commission	Public Health Service	Community Planning and Development	Federal Housing Administration	Bureau of Land Management	Bureau of Reclamation	Geological Survey	Fish and Wildlife Service	Coast Guard	Federal Aviation Administration	Federal Highway Administration	Federal Railway Administration	Federal Insurance Administration	State and Local Programs and Support Directorate			International Boundary and Water Commission (U.S. Section)
Flood Insurance Studies*	–	–	–	–	–	*	*	–	–	–	–	–	–	–	–	–	*	–	–	–	–	–	S	–	–	*	–
Flood Plain Management Services	–	–	–	–	–	S	S	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	S	–	–	S	–
Flood Plain Information Studies and Reports																											
Riverine	–	–	–	–	–	S	S	–	–	–	–	–	–	S	–	–	S	S	–	–	–	–	F	–	–	S	–
Coastal	–	–	–	–	–	I	S	G	–	–	–	–	–	S	–	–	I	S	–	–	–	–	F	–	–	–	–
Technical and Planning Services**																											
Full Program	–	–	–	–	–	S	S	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	F	–	–	S	–
Program Elements	–	–	I	G	I	S	S	I	S	S	I	–	–	S	I	I	S	–	–	I	I	I	–	I	–	S	–
Flood Modifying Construction	–	–	–	G	I	S	S	–	F	–	–	–	–	–	–	–	–	–	–	I	–	–	–	F	–	S	S
Flood Preparedness, Emergency, and Recovery	–	F	–	G	S	S	S	G	–	–	–	S	G	–	–	–	S	–	S	–	–	–	G	SG	G	–	S
Warning and Forecasting	–	–	–	–	–	–	S	S	–	–	–	–	–	–	–	–	S	–	–	–	–	–	–	I	–	–	S
Research	S	–	S	–	I	I	S	S	S	–	–	–	–	–	–	S	S	S	–	–	–	–	–	–	–	–	–
Open Space	–	–	–	–	I	S	–	G	–	–	–	–	G	–	–	–	–	S	–	–	–	–	I	–	–	–	–

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

S. Staff and Funds
F. Funds
G. Grants and Loans
I. Incidental

Source: Adapted from Federal Interagency Floodplain Management Task Force. A Unified National Program for Floodplain Management. 1986.

Figure 7-1. Federal Flood Loss Reduction and Related Programs by Agency.

5) Establish — with presidential approval — principles, standards, and procedures for federal participation in river basin planning, and for formulation and evaluation of water projects — whether or not they originated in river basin plans.

6) Review plans submitted by the river basin commissions created pursuant to Title II of the Water Resources Planning Act and send them, together with Council recommendations, to the President.

Under Title II of the Water Resources Act, the WRC was authorized to participate in the creation, operation, and termination of interstate, intergovernmental river basin planning commissions. Title III authorized the WRC to make financial grants to states for assistance in developing and participating in comprehensive water and related land resources plans. Many persons now working in the field of floodplain management owe their start to the opportunities provided by the development of river basin plans and state water plans funded under Title III (Owen, 1989).

Holmes (1979) notes that, in part because the "Council" was composed of the secretaries of agencies involved in water resources, the WRC was often criticized as an ineffectual agency that placed too much emphasis on planning instead of becoming more involved in important policy decisions. Each agency was likely to benefit from improved planning, but one or more agencies might lose as a result of resolution of policy disputes, hence the avoidance of policy issues. Nevertheless, the WRC undertook numerous activities important to floodplain management, including implementation of several of the recommendations presented in House Document 465. Holmes also suggested that "WRC's most important policy studies and recommendations (with the possible exception of its work on the discount rate) were those that concerned flood damage reduction by nonstructural means." Several of the major water resource and floodplain management activities undertaken by the WRC during its 16 years of operation are listed below and described more fully in following sections of the *Assessment Report.*

- Executive Order 11296 (1966)
- Flood Hazard Evaluation Guidelines
- National Water Assessment
- Discount Rate for Water Projects
- Principles and Standards for Water and Related Land Resources
- Guidelines for Determining Flood Flow Frequency
- State and Local Floodplain Regulation
- Floodplain Management Guidelines for Implementing E.O. 11988
- Unified National Program for Floodplain Management
- Interagency Floodplain Management Task Force

In 1982, the WRC was dismantled following termination of its funding.

River Basin Commissions

The Water Resources Planning Act of 1965 also authorized the establishment of river basin commissions (RBCs). Although the Water Resources Council was active in promoting the establishment of river basin commissions and much of their funding was provided by the WRC, the RBCs considered themselves independent of the WRC. Four RBCs were formed by 1967: the New England River

Basins Commission, Great Lakes Basin Commission, Pacific Northwest RBC, and the Souris-Red-Rainy RBC. In 1971, the Ohio RBC was formed, and in 1972 the Missouri and Upper Mississippi RBCs were established. In 1973, the Upper Mississippi RBC incorporated the Souris-Red-Rainy RBC, leaving a total of six RBCs.

The Water Resources Planning Act required the RBCs to prepare "comprehensive, coordinated, joint plans" (CCJPs) for their region or basin. No definition or guidance regarding preparation of a CCJP was issued by the WRC, and each RBC prepared the plans according to their own concepts, and the results ranged from a collection of issue-focused studies to a collection of comprehensive river basin plans (Field, 1979).

Beginning in 1982, the RBCs began to close their operations following the removal of federal funding. Some managed to remain in operation for a few years with funding by member states but by 1988 only the Missouri RBC remained. The Delaware River Basin Commission and the Susquehanna River Basin Commission, which were formed as federal-state compact commissions, remain in existence with federal and state funding.

Executive Orders and Guidelines for Floodplain Management

Two Presidential executive orders, guidance for implementing the orders, and subsequent actions by federal agencies have played a major role in floodplain management at the federal level.

- **Executive Order 11296, 1966.** Executive Order 11296, "Evaluation of Flood Hazard in Locating Federally Owned or Financed Buildings, Roads, and Other Facilities, and in Disposing of Federal Lands and Properties," was issued in 1966 at the same time that the President transmitted the report on a Unified National Program for Reducing Flood Losses to the Congress. This Executive Order recognized that federal government programs and financial assistance exert strong direct and indirect influences on development within floodprone areas. It directed federal executive agencies to "provide leadership in encouraging a broad and unified effort to prevent uneconomic uses and development of the Nation's flood plains and, in particular to lessen the risk of flood losses in connection with Federal lands and installations and federally financed or supported improvements." In effect, the order directed all federal agencies responsible for construction and operation of federal facilities, administration of federal grant, loan or mortgage insurance programs involving construction, disposal of federal lands or properties, and programs involving land-use planning, to: 1) evaluate flood hazards before taking any of these actions; 2) limit land use in proportion to the degree of flood hazard involved; and 3) avoid uneconomic, hazardous or unnecessary use of floodplains.

- **Flood Hazard Evaluation Guidelines, 1969 and 1972.** In 1969, the WRC released *Proposed Flood Hazard Evaluation Guidelines for Federal Agencies* for use by federal agencies in complying with E.O. 11296. Following a year of review and testing by 75 federal executive agencies, and review by state and local agencies and the private sector, the proposed guidelines were revised and issued in 1972 as *Flood Hazard Evaluation Guidelines for Federal Executive Agencies* (U.S. Water Resources Council, 1972).

- **Executive Order 11988, 1977.** Executive Order 11988, "Floodplain Management," was issued by the President in May 1977 to bring together federal policies to protect against both flood hazards and degradation of floodplain natural resources. E.O. 11988 superseded and expanded E.O. 11296. A 1975 General Accounting Office (GAO) report found that "Executive Order 11296 proved to have a limited effect in reducing flood losses due to the lack of agency implementing procedures and limited compliance by Federal agencies" (Federal Emergency Management Agency, 1983).

  The 1977 Executive Order was intended to increase the effectiveness of federal agencies' actions related to floodplain management. In addition, it expanded the scope of E.O. 11296 by requiring that federal agencies also address the need to diminish environmental damage due to unwise planning and development of floodplains.

  E.O. 11988 established general policy bringing together concerns for human safety, health and welfare, and property with concerns for restoring and preserving natural and beneficial resources of floodplains. Federal agencies were directed to:

  - avoid directly or indirectly supporting floodplain development;
  - avoid actions located in or affecting the floodplain, unless the floodplain location is the only practicable alternative;
  - in the absence of a practicable alternative, require that actions be designed or modified in order to minimize potential harm to or within the floodplain; and
  - use the one percent annual chance flood standard in evaluating proposed actions affecting the floodplain.

  The executive order, which applies to proposed actions of federal agencies, required each agency to issue implementing procedures and provided for public participation in federal decisions affecting floodplains (Federal Emergency Management Agency, 1983).

- **WRC Guidelines for Federal Agencies, 1978.** In 1978, the Water Resources Council issued a set of guidelines (Guidelines) for use by federal agencies in implementing E.O. 11988 (U.S. Water Resources Council, 1978). The Guidelines were intended to provide broad guidance for interpretation of the Executive Order and to assist the federal agencies in developing their own procedures for complying with the executive order. The WRC Guidelines, the result of a 12-month interagency task force effort, included an eight-step decision-making process to be followed by federal agencies when applying E.O. 11988 to their actions.

  The Guidelines also spelled out the responsibilities of the agencies to: 1) recognize that floodplains have unique and significant public values; 2) evaluate the potential effects of any action that they may take in a floodplain; and 3) take floodplain management into account both in formulating their own water and land-use plans, and in evaluating the water and land-use plans of others. In 1987, the Federal Interagency Floodplain Management Task Force issued an interim document providing additional guidance on implementation of E.O. 11988 (Federal Interagency Floodplain Management Task Force, 1987).

Guidelines for Determining Flood Flow Frequency

The WRC, through its hydrology committee, began work on determining the best methods of flood frequency analysis in 1966. The efforts of the committee were published in 1967 as Bulletin No. 15, *A Uniform Technique for Determining Flood Flow Frequencies.* The techniques presented in the Bulletin were adopted by the WRC for use in all federal planning involving water and related land resources, and recommended for use by state and local government and private organizations. Efforts to improve the recommended methodologies continued, and in 1976 an extension and update was published as Bulletin No. 17, *Guidelines for Determining Flood Flow Frequency.* A second revision published in 1981 as Bulletin No. 17B (U.S. Water Resources Council, 1981) stands as the guidance used by practically all government agencies in undertaking flood frequency studies.

Discount Rate for Water Projects

In response to a presidential directive, the WRC in 1968 modified the formula for determining the discount rate used in estimating the benefit/cost ratios of proposed water resources projects, including flood control projects. This change resulted in a substantial increase in the discount rate and contributed to a decline in new water resource projects. Also as a result of the change in the formula, some projects authorized in the 1950s but not yet constructed were deauthorized (Holmes, 1979).

National Flood Insurance Program

At the same time that the President's Task Force on Flood Loss Reduction was preparing its reports in 1965 and 1966, the Department of Housing and Urban Development, as authorized by The Southeast Hurricane Disaster Relief Act of 1965 (P.L. 89-339), was conducting a feasibility study for a national flood insurance program. Recommendations resulting from this study served as the basis for the National Flood Insurance Act (NFIA) of 1968 (Title 13 of P.L. 90-448) which established the National Flood Insurance Program within HUD. Administrative responsibility for the NFIP was established in the Federal Insurance Administration in HUD.

> *The NFIP was designed to reduce future flood losses through state and local floodplain management efforts and to transfer the costs of residual flood losses from the general taxpayer to the floodplain occupant. This program represented a major shift in strategy from previous structural flood control and disaster relief efforts* (U.S. Water Resources Council, 1979).

The following federal acts provide the legislative authorities for the NFIP.

- **National Flood Insurance Act of 1968.** The NFIA established the NFIP as a voluntary program in which identified floodprone communities were encouraged to participate. Communities that joined the program were required to adopt minimum regulations governing development in identified flood hazard areas, and in exchange the FIA would make flood insurance (substantially subsidized by the federal government) available to any structure within the community (even those structures outside an identified floodprone area). The FIA was authorized to conduct flood risk studies (Flood Insurance Studies) and prepare maps of flood hazard areas in all communities identified as floodprone.

• SECTION 1302: Section 1302 of the NFIA stated a number of Congressional findings relating to floods and the need for a national program of flood insurance, and it listed several purposes of the Act. From Section 1302:

> *(c) The Congress further finds that (1) a program of flood insurance can promote the public interest by providing appropriate protection against the perils of flood losses and encouraging sound land use by minimizing exposure of property to flood losses; and (2) the objectives of a flood insurance program should be integrally related to a unified national program for flood plain management and, to this end, it is the sense of Congress that within two years following the effective date of this title the President should transmit to the Congress for its consideration any further proposals necessary for such a unified program, including proposals for the allocation of costs among beneficiaries of flood protection.*
>
> *(d) It is therefore the purpose of this title to (1) authorize a flood insurance program by means of which flood insurance, over a period of time, can be made available on a nationwide basis through the cooperative efforts of the Federal Government and the private insurance industry, and (2) provide flexibility in the program so that such flood insurance may be based on workable methods of pooling risks, minimizing costs, and distributing burdens equitably among those who will be protected by flood insurance and the general public.*
>
> *(e) It is the further purpose of this title to (1) encourage State and local governments to make appropriate land-use adjustments to constrict the development of land which is exposed to flood damage and minimize damage caused by flood losses, (2) guide the development of proposed future construction, where practicable, away from locations which are threatened by flood hazards, (3) encourage lending and credit institutions, as a matter of national policy, to assist in furthering the objectives of the flood insurance program, (4) assure that any Federal assistance provided under the program will be related closely to all flood-related programs and activities of the Federal Government, and (5) authorize continuing studies of flood hazards in order to provide for a constant reappraisal of the flood insurance program and its effect on land-use requirements.*

• SECTION 1362: Section 1362 of the NFIA authorized the Secretary of HUD to purchase from willing sellers certain insured properties located in flood risk areas and to transfer the purchased properties to state or local governments. To qualify for purchase, properties must have been damaged substantially beyond repair by flooding, or damaged by floods on not less than three previous occasions in five years with the cost of repair averaging at least 25 percent of the value of the structure. Section 1362 provided an opportunity for a federal agency to establish a continuing program to purchase properties for the specific purposes of reducing future flood losses, as opposed to purchasing properties as part of an individual project.

- **Housing and Urban Development Act of 1969.** The Housing and Urban Development Act of 1969 (P.L. 91-152) amended the NFIA in two important respects. First, it established the emergency phase of the NFIP, permitting property owners to purchase limited amounts of flood insurance at federally subsidized rates prior to completion of detailed flood insurance studies and maps. The availability of flood insurance gave communities an incentive to join the NFIP. Second, it added damage and loss resulting from mudslides caused by accumulations of water on or under the ground as an eligible component of the NFIP.

- **Flood Disaster Protection Act of 1973.** Following disastrous flooding in 1972 at Rapid City, South Dakota and in several eastern states affected by Hurricane Agnes, it was found that very few flood victims had purchased flood insurance. As a result, Congress strengthened the NFIP through amendments in the Flood Disaster Protection Act of 1973 (P.L. 93-234). This Act provided incentives for communities to join the NFIP by: 1) substantially increasing the amounts of flood insurance coverage available; and 2) providing penalties for both communities and individuals that chose not to join the NFIP and were subsequently flooded.

  - SECTION 102(a): Required the purchase of flood insurance in communities where such insurance was available in conjunction with any form of federal financial assistance for acquisition or construction located in identified special flood hazard areas.

  - SECTION 102(b): Required purchase of flood insurance when property located in the floodplain was to be secured by a conventional mortgage from a federally related lender (includes loans, grants, guaranty, insurance and other forms of direct or indirect federal financial assistance other than general or special revenue sharing or formula grants to states).

  - SECTIONS 202 (a) and (b): Communities identified by FEMA as floodprone were allowed one year after such identification to enroll in the NFIP or thereafter be denied both direct and indirect federal financial assistance for acquisition or construction purposes in flood hazard areas.

  The 1973 Flood Disaster Protection Act also added damage and loss resulting from erosion and undermining of shorelines by waves or currents "exceeding anticipated cyclical levels" as eligible components of the NFIP.

- **The Housing and Community Development Act of 1977.** The Housing and Community Development Act of 1977 (P.L. 95-128) contained three major amendments to the NFIP: 1) the provisions withholding benefits from nonparticipating communities were substantially relaxed; 2) the coverage limits for communities in the Regular Program were raised; and 3) the authority to purchase flood-damaged property under Section 1362 was expanded to include properties damaged from causes other than flooding and to authorize low-interest loans for floodproofing structures located within the designated floodway.

- **Omnibus Budget Reconciliation Act of 1981.** Section 341 of the Omnibus Budget Reconciliation Act (OBRA) amended the NFIA to prohibit the issuance of any federal flood insurance coverage after October 1, 1983 for any new construction or substantial improvements of structures located on undeveloped coastal barriers.

The OBRA established a precedent for withdrawal of federal financial assistance for development as one means of protecting coastal barriers and reducing recurring federal costs of protecting coastal barriers and reducing recurring federal costs associated with their development and reconstruction (U.S. Department of the Interior, 1988).

- **Coastal Barrier Resources Act of 1982.** Section 10 of the Coastal Barrier Resources Act (CBRA, P.L. 97-348) repealed Section 341 of the OBRA, but retained the OBRA prohibition against federal flood insurance for new construction or substantial improvements on structures on undeveloped coastal barriers on or after October 1, 1983. However, the CBRA expanded the scope of the prohibition of federal expenditures and financial assistance to include all federal programs that support development on the undeveloped coastal barriers within the Coastal Barrier Resources System (CBRS). These additional prohibitions, with several exceptions for conservation, public recreation, research, national security, and other considerations, became effective October 18, 1982 (U.S. Department of the Interior, 1988).

- **Water Resources Development Act of 1986.** Section 402 of this Act (P.L. 99-662), as amended, requires nonfederal interests to participate in and comply with the NFIP before construction of any federally financed local flood protection project or any project for hurricane or storm damage reduction.

- **The Housing and Community Development Act of 1987.** Section 544 of The Housing and Community Development Act of 1987 (P.L. 100-242) authorized prepayment of flood insurance for structures in imminent danger of collapse due to coastal erosion (including structures on the shorelines of lakes, rivers and other water bodies in addition to the ocean). Insurance payments may be provided either to relocate the structure further away from the shore (minimum setbacks are specified) or to demolish the structure.

Actions to Improve Dam Safety

A series of dam failures and near failures in the early 1970s focused attention on the safety of water storage dams and resulted in a number of legislative and presidential actions intended to improve both federal and state responsibilities for dam safety.

- **National Dam Inspection Act of 1972.** The National Dam Inspection Act of 1972 (P.L. 92-367) required the U.S. Army Corps of Engineers (Corps) to inventory all nonfederal dams in the United States, and to carry out a program of safety inspections of all medium and high hazard dams except for those under the jurisdiction of specified federal agencies and certain other classes of dams (National Research Council, 1982).

- **Presidential Directives.** In April 1977, President Carter directed the following actions: 1) that federal agencies having responsibilities for dams undertake reviews of practices that could affect dam safety; 2) that the Chairman of the Federal Coordinating Council for Science Engineering and Technology (FCCSET) convene an ad hoc interagency committee to coordinate dam safety programs; and 3) that the Director of the Office of Science and Technology Policy arrange for a review of federal agency practices by an independent panel of recognized experts. In November of 1977, the President also directed the Corps, in cooperation with the states, to proceed under authority of P.L. 92-367 to inspect nonfederal dams classed as "high hazard" because of downstream development.

In June 1979, the *Federal Guidelines for Dam Safety* prepared by the Ad Hoc Interagency Committee on Dam Safety were released. In July 1979, as part of Executive Order 12148 establishing the Federal Emergency Management Agency, FEMA was directed to coordinate federal dam safety efforts. In October of 1989, President Carter directed the head of each federal agency having responsibilities for dams to adopt and implement the *Federal Guidelines for Dam Safety*.

- **Dam Safety Act of 1986.** The Dam Safety Act of 1986 (Title 12 of P.L. 99-662) authorized federal financial and other assistance to state dam safety programs.

Principles and Guidelines for Water and Related Land Resources

The "Principles and Standards for Planning of Water and Related Land Resources" adopted by the Water Resources Council in 1973 were revised and issued as the "Economic and Environmental Principles and Guidelines for Water and Related Land Resources for Implementation Studies" in 1983.

- **Principles and Standards.** In 1973, the WRC adopted the "Principles and Standards for Planning of Water and Related Land Resources" (U.S. Water Resources Council, 1973). The Principles and Standards provided standards for project-scale planning and evaluation, while recommending that river basin planning provide the basis for project-scale planning, including dams and reservoirs and other flood control projects. As part of the evaluation process, proposed actions were to be evaluated according to three accounts: "National Economic Development," "Environmental Quality," and "Social Well Being." The Principles and Standards represented "a major attempt at standardizing federal water resources efforts by establishing detailed plan formulation procedures and a system for displaying impacts of alternative plans on multiple objectives" (Field, 1979).

- **Water Resources Development Act of 1974.** Section 80(c) of this Act directed the President to investigate and study the "Principles and Standards for Planning and Evaluating Water and Related Resources Projects." Responsibility for conducting the study was assigned to the WRC. An interagency study team was developed and a 22-volume report was released in 1975 (Buie, 1979).

- **Principles and Guidelines.** In 1983, the Principles and Standards were revised and issued as the "Economic and Environmental Principles and Guidelines for Water and Related Land Resources for Implementation Studies." These Principles and Guidelines provide for greater flexibility in the application of procedures and decision-making processes than the previous Principles and Standards. The 1983 Principles and Guidelines dropped the Environmental Quality and Social Well Being accounts and rely only on the National Economic Development account for project justification.

In addition to evaluation of existing activities, available services, and other attributes of the floodplain, the Principles and Guidelines declare that the potential of the floodplain for natural and beneficial values, including open space, recreation, wildlife, natural flood storage, and wetlands should be recognized and displayed in the valuation of alternatives. (Interagency Task Force on Floodplain Management, 1986.)

Consideration of Nonstructural Approaches

Consideration of nonstructural floodplain management approaches was authorized and promoted by the Water Resources Development Act of 1974 and the 1980 Interagency on Nonstructural Measures.

- **Water Resources Development Act of 1974.** Section 73 of the Water Resources Development Act of 1974 (P.L. 93-251) directed all federal agencies to consider nonstructural approaches in federal water resource projects. This Act also authorized acquisition of floodprone property for three specific projects: 1) purchase of wetlands for flood storage in the Charles River basin near Boston, Massachusetts; 2) acquisition of floodprone properties in Prairie du Chien, Wisconsin; and 3) acquisition of properties affected by subsidence and coastal flooding in a section of Baytown, Texas.

- **1980 Interagency Agreement on Nonstructural Measures.** An interagency agreement — "Use of Nonstructural Measures in Flood Damage Reduction and Floodplain Management" — was developed in 1980 to establish common policy among the water resource construction agencies for nonstructural flood loss reduction (Thomas, 1983).

Disaster Assistance

The Disaster Relief Act of 1974 and the Disaster Relief and Emergency Assistance Amendments of 1988 established important requirements and opportunities pertaining to the availability of disaster assistance.

- **Disaster Relief Act of 1974.** Section 406[1] of the Disaster Relief Act of 1974 (P.L. 93-288) required states applying for disaster assistance to take action to mitigate hazards as a condition of receiving disaster assistance. Section 406 also required that rebuilding be done in conformance with applicable codes, specifications and standards (Federal Emergency Management Agency, 1981). The 406 requirements tied the receipt of federal grants or loans for disaster assistance to a state's evaluation of natural hazards and identification of appropriate actions to mitigate such hazards.

- **Disaster Relief and Emergency Assistance Amendments of 1988.** The Disaster Relief and Emergency Assistance Amendments of 1988 (P.L. 100-707) made a number of important changes

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[1] Section 406 was renumbered as Section 409 by the Disaster Relief and Emergency Assistance Amendments of 1988 (P.L. 100-707).

in disaster relief programs, including: making hazard mitigation eligible for federal funding; setting the minimum federal share of disaster assistance at 75%; providing for a 50/50 federal/state matching grant for FEMA-approved hazard mitigation projects (with the federal contribution limited to 10% of the cost to repair, replace or restore damaged public facilities); increasing federal matching grants for state preparedness planning from $25,000 to $50,000; establishing a Great Lakes program providing grants to states to combat erosion and high water levels in the Great Lakes; and prohibiting new construction in erosion-prone areas from receiving disaster relief (Butler, 1989).

Pre- and Postdisaster Planning

Important pre- and postdisaster planning activities were authorized by the Disaster Relief Act of 1974 and the 1980 Interagency Agreement on Nonstructural Measures.

- **Disaster Relief Act of 1974.** Section 201 of the Disaster Relief Act of 1974 (P.L. 93-288) provided FEMA with authority to provide assistance to states to conduct Quantitative Hurricane Preparedness Studies. FEMA established a cooperative program with the National Weather Service's National Hurricane Center and the Corps of Engineers to assist states along the Gulf and Atlantic coasts in the development of hurricane preparedness plans (Federal Emergency Management Agency, 1987).

  As previously described, Section 406 of the Disaster Relief Act of 1974 required states to develop hazard mitigation plans in order to remain eligible for disaster assistance funds. While many state and local communities had previously been involved in hazard mitigation, Section 406 planning requirements made the evaluation of mitigation opportunities mandatory after a presidential declaration of disaster.

- **1980 Interagency Agreement on Nonstructural Measures.** In 1980, the Office of Management and Budget (OMB) directed that "all Federal programs that provide construction funds and long-term recovery assistance must use common flood disaster planning and postflood recovery procedures" (Office of Management and Budget, 1980). In response, 12 federal agencies signed an Interagency Agreement (1980) to provide technical assistance to states and communities for nonstructural flood damage reduction measures. Representatives from each agency formed an Interagency Flood Hazard Mitigation Task Force charged with carrying out the terms of the agreement. The Task Force representatives ensure that technical personnel from their agencies are available to participate on postdisaster interagency hazard mitigation teams. Task Force representatives also review agency programs and policies to identify and remove obstacles to implementing flood hazard mitigation measures recommended by the interagency teams.

Federal Interagency Floodplain Management Task Force

The Federal Interagency Floodplain Management Task Force was established in 1975 to carry out the responsibility of the President to prepare for the Congress a Unified National Program for Floodplain Management. Current membership of the Task Force consists of: the Departments of

Agriculture, Army, Commerce, Energy, Housing and Urban Development, Interior, and Transportation; the Environmental Protection Agency; the Tennessee Valley Authority; and the Federal Emergency Management Agency. The Task Force was chaired by a representative from the Water resources Council until 1982 when the chairmanship shifted to a FEMA representative (Thomas, 1988). The Task Force has undertaken or sponsored several important initiatives and studies, some of which are listed below (Federal Interagency Floodplain Management Task Force, 1986):

- *Nonstructural Floodplain Management Study: Overview*, (White, 1978).
- *Floodplain Acquisition: Issues and Options in Strengthening Federal Policy*, (Kusler, 1978).
- *Improved Formulation and Evaluation of Nonstructural Elements for Water Resources Plans in Flood Hazard Areas*, (Shabman, 1979).
- *Options to Improve Federal Nonstructural Responses to Flood*, (Platt, 1979).
- *Economic Aspects of Wildlife Habitat and Wetlands*, (Midwest Research Institute, 1979).
- *Emerging Issues in Wetland/Floodplain Management — Supporting Materials for a Report of a Technical Seminar*, (Kusler, 1979).
- *Emerging Issues in Wetland/Floodplain Management — Summary Report of a Technical Seminar Series*, (Kusler, 1979).
- *Sources of Wetlands/Floodplain Research Information*, (1980).
- *Workshop Report on Bottomland Hardwood Wetlands*, (National Wetlands Technical Council, 1980).
- *Nonstructural Measures in Flood Damage Reduction Activities*, (Galloway, 1980).
- *The Influence of Regulations and Practices on the Implementation of Nonstructural Flood Plain Plans*, (CME Associates, Inc., 1980).
- *An Assessment of Storm Surge Modeling*, (Hydrology Committee, 1980).
- *State and Local Acquisition of Floodplains and Wetlands*, (Field Associates, 1981).
- *Analysis of Methodologies Used for the Assessment of Wetland Values*, (USA Waterways Experiment Station, 1981).
- *Floodplain Management Handbook*, (Owen, 1981).
- *Cooperative Flood Loss Reduction: A Technical Manual for Communities and Industry*, (Owen, 1981).
- *Estimating Peak Flow Frequencies for Natural Ungaged Watersheds (A Proposed Nationwide Test)*, (Hydrology Committee, 1981).
- *Evaluating the Effectiveness of Floodplain Management Techniques and Community Programs*, (1985).
- *A Unified National Program for Floodplain Management*, (1986).
- *Further Advice on Executive Order 11988, Floodplain Management*, (1987).

A Unified National Program for Floodplain Management

The Bureau of Budget assigned primary responsibility to the Water Resources Council for carrying out the recommendations presented by the President's Task Force on Flood Loss Reduction as published in H.D. 465. The WRC refined and expanded the Task Force's report, and the first report entitled *A Unified National Program for Floodplain Management* (U.S. Water Resources Council, 1976) was published in 1976. This document prescribed specific strategies and tools for flood loss reduction. The Unified National Program was revised in 1979 (U.S. Water Resources Council, 1979) and expanded to include strategies and tools for management of natural floodplain resources. Further update and revision occurred in 1986 (Federal Interagency Floodplain Management Task Force, 1986).

Federal Emergency Management Agency

The Federal Emergency Management Agency was created in 1979 by Executive Order 12127. Several agencies and programs of different federal departments were combined into FEMA, including the Federal Insurance Administration and the Federal Disaster Assistance Administration which were transferred from HUD, and the Defense Civil Preparedness Agency, among others. This combination of agencies gave FEMA the lead in promoting nonstructural approaches to floodplain management, and at the same time closely aligned floodplain management with emergency management.

Federal Crop Insurance Act of 1980

The U.S. Department of Agriculture (USDA) has provided some form of crop insurance to farmers since 1938. Prior to 1980, crop insurance was limited and the USDA provided disaster assistance mainly through loans and direct cash payments to affected farmers. In 1980, the Federal Crop Insurance Act of 1980 (P.L. 96-365) greatly expanded the scope and availability of crop insurance to include more crops and to apply in over 3,000 agricultural counties in 50 states. The objective of the crop insurance program is to improve economic stability of agriculture by providing multi-peril crop insurance for individual producers of commercially grown commodities. The crop insurance program is administered by the Federal Crop Insurance Corporation within the USDA (Harman, 1990; U.S. General Services Administration, 1990).

Bureau of Reclamation Reorganization, 1987

The Bureau of Reclamation within the Department of Interior (DOI) was originally charged under the Reclamation Act of 1902 to administer a reclamation program that would provide the arid and semiarid lands of the 17 contiguous western states with a secure, year-round water supply for irrigation. Over the years, the BOR's mission was expanded to include provision of water supply for communities and industry as well as generation of hydroelectric power, river regulation and flood control, provision of outdoor recreation opportunities, and the enhancement and protection of fish and wildlife habitats (Office of the Federal Register, 1987). In large part, the role of the BOR has been to plan, construct, and manage large dam and reservoir projects, including flood control projects and multipurpose reservoirs.

In a report it published in 1987, the BOR recognized its role was changing from that of constructing major water development projects to developing solutions for the conservation of water and protection of the environment. The BOR's current objectives are to improve management and use of resources by increasing water and power operating efficiencies, and identifying new opportunities for nonfederal partnerships in water resource development. These objectives will largely be met by integrating existing systems and making them more reliable. The BOR will also seek to manage its projects to provide greater opportunities for the public to enjoy recreational activities and protect the valuable cultural and natural resources associated with its projects. The BOR will therefore continue to play an important role in future floodplain management activities (Brown, 1989).

STATE AND COMMUNITY FRAMEWORK FOR FLOOD LOSS REDUCTION

Major changes have occurred in the management framework for flood loss reduction at the state and local level over the past 25 years. In addition to the following descriptions, details and examples of state and local activities are included in chapters 11, 12 and 13 of the *Assessment Report.*

Flood Loss Reduction at the State Level

State organization and activities for flood loss reduction have responded to, and in many respects paralleled, activities at the federal level as a result of federal legislation, programs and funding. Two state level changes are perhaps most significant because they have directly affected every state and practically every floodprone community in the United States.

The first of these changes established state administration of local floodplain management regulations through a state flood insurance coordinator. As a result of the NFIP, each state now has a flood insurance coordinator and some type of program for working with and providing floodplain management assistance to local communities throughout the state. Each state has enacted some form of enabling legislation permitting local governments to adopt floodplain regulations (Association of State Floodplain Managers, 1988).[2]

The second major change is that each state now has developed a multi-hazard emergency operations plan administered by the state's emergency or civil preparedness agency. These multi-hazard emergency operations plans generally contain annexes or appendices dealing specifically with different types of hazards, including floods, hurricanes, and other types of flood-related hazards.

Every state continues to have some agency involved in planning, funding, or sponsoring structural flood control projects. State involvement in dam safety activities increased greatly during the 1980s.

In addition to the just-described activities that have been undertaken by every state, a variety of other actions have enhanced the states' abilities to reduce flood losses. For example, several states have adopted their own statewide floodplain management regulations that parallel or, in some cases, contain more stringent requirements than those of the NFIP. In other states, executive orders have been issued (similar to federal Executive Order 11988) requiring state agencies to take flood hazards into consideration when siting facilities or initiating other actions affecting floodplains.

All coastal states have responsibilities and some type of permitting program for activities occurring below mean high water — the area held in public trust by the states for all the people of the state. While state programs vary considerably, these programs typically involve review of flood damage

[2] In 1989, the Missouri Supreme Court ruled that, under state law, counties could not regulate development in a special flood hazard area on land used for agricultural purposes. Furthermore, many of these counties did not have the authority to regulate the activities of levee and drainage districts. Absence of this authority meant that the counties could no longer enforce the minimum floodplain management requirements for participation in the NFIP (Watson, 1990). The Missouri legislature initiated action to address this deficiency in late 1990, and passed necessary legislative amendments to remedy the problem in February 1991 (Federal Emergency Management Agency, 1991).

potential, impacts on tidal wetlands, and other factors in considering whether a proposed activity will be in the public interest.

For the most part, each state carries out the same types of activities for flood loss reduction, although each state has its own unique administrative organization, and the level of activity varies greatly depending on many factors, including the frequency and severity of flooding the state has experienced.

Flood Loss Reduction at the Community Level

At the community level, the most dramatic change in the management framework for flood loss reduction since the 1960s has been the widespread adoption and enforcement of local floodplain regulations under the NFIP. There are now some 18,000 communities that have elected to participate in the NFIP and that have adopted at least minimum floodplain regulations. Although many of these communities have not warmly embraced floodplain regulation, by and large they have come to recognize the importance of taking action through local land-use regulation to protect people and property from flood losses. Consequently, regulatory action at the community level is now the most widespread and effective means of reducing flood losses to new development.

Largely in response to state requirements, many communities have also developed multi-hazard emergency preparedness or operations plans. Although relatively few communities have developed specific flood emergency plans, the development of multi-hazard plans is widely viewed as greatly increasing community flood preparedness and contributing to improved flood warning and loss reduction.

Flood control structures are still widely viewed as a preferred means of reducing flood losses, and many local communities participate as sponsors for local structural flood control works, typically through a public works department. The local governmental unit usually provides only a small contribution to the cost of these structural flood control works, and relies heavily on federal and state governmental units for both funding and expertise. In contrast, local governments are almost exclusively responsible for local drainage and stormwater management to control localized flooding. As the Nation has become more urbanized, drainage control and stormwater management has become a major local government activity and an important component of a total floodplain management program.

Intergovernmental and Regional Government Management[3]

Regional approaches to floodplain management, carried out on an intermediate scale between local and state government efforts, are often overlooked or their effects underestimated. Opportunities for developing regional approaches, however, are especially important because flooding is not limited

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3 A 1987 study entitled *Regional Management of Metropolitan Floodplains* edited by Rutherford H. Platt addresses various opportunities and approaches for responding to flooding by regional entities. This section on Intergovernmental and Regional Government Management is based largely on material included in that study.

by political boundaries. Since government jurisdictions do not conform to watershed boundaries, the local, state and federal approach to floodplain management can be fragmented and weakened when applied to individual communities and floodplains. Management authorities can be divided between local, state and federal governments, between several different municipalities with jurisdiction in the same floodplain, and among different agencies in each unit of government involved.

Among the entities that can contribute to floodplain management on a regional level are: 1) special districts; 2) county governments; 3) private conservation groups; and 4) conservation districts.

- **Special Districts.** Special districts are sub-state government units created by state legislation and are the most numerous and fastest growing type of government entity in the United States (28,733 existed in 1982). Special districts perform a wide range of public and quasi-public services and have many of the same powers as municipalities (e.g., the right to sue and be sued, to own property, to enter into contracts, and to levy taxes or raise funds in other ways). Unlike municipalities, however, the functions of special districts are limited to one or more responsibilities as defined by state law.

  Many special districts have been created in response to federal programs, and nearly one fourth of all special districts have natural resource-related functions. Many special districts are concerned with water resources issues such as soil and water conservation, drainage, flood control, and irrigation.

  The 1982 *Census of Governments* listed 2,705 "drainage and flood control" districts nationally, 2,421 "soil and water conservation districts," and 1,617 "sewerage districts." Some of these districts existed "on paper" only (without active programs); many are too small to be considered regional in scope.

  Regional special districts may have several advantages over other units of government in accomplishing effective flood loss reduction. These advantages include: 1) area-wide jurisdiction (districts may be large enough to encompass entire watersheds); 2) flexible boundaries (to encompass necessary hydrologic units); 3) fiscal autonomy (not as dependent on federal and state sources of funds); 4) legal flexibility; 5) professionalism; and 6) intergovernmental cooperation opportunities. Possible disadvantages of special districts may include less public accountability and a more narrow perspective than other units of government (Platt, 1987).

- **County Governments.** The Nation's 3,041 counties cover nearly all of the land area of the United States and overlie most municipalities and special districts within metropolitan areas. Counties vary greatly in extent of jurisdiction, budgets, authorities, and political characteristics. For example, while county governments are relatively weak or nonexistent in the Northeast, strong county governments in the South and West have thousands of employees and provide a wide range of public services.

  Counties may serve as local governments for certain purposes and regional governments for others, and may provide services through either direct authority under state law or intergovernmental agreements with other units of government. County-wide functions pertaining to flood hazards may include the development of storm drainage systems, floodplain land acquisition, flash flood warning systems, and emergency response measures. Some counties are also authorized to engage in land-use planning.

A survey of the roles and programs of 52 selected metropolitan counties relative to floodplain management (Platt, 1987a; Platt, undated) showed that, in general, the Northeast and North Central counties reported the application of fewer flood loss reduction measures per county than counties in the South and West. (County governments are generally weaker in the older, industrial metropolitan areas of the northern regions.) The most active counties in terms of implementing flood loss reduction measures were seen to be those experiencing rapid "sun belt" growth in the South and West, where flash flooding and coastal storms are important concerns.

The most frequently applied measure by the counties surveyed was "minimum building elevation requirements" and the least frequently applied was "relocation of structures from floodplains." Two types of measures were found to be usually applied on a county-wide basis: structural flood control measures and emergency warning and assistance measures. By contrast, regulatory land-use control measures, floodplain land acquisition, and measures to relocate structures are usually limited to unincorporated areas within county jurisdictions. Such controls are traditionally the responsibility of local government.

A great diversity was found among the counties with regard to the types and combination of measures used and the geographic areas within which they are applied. It was also found that counties are not well informed of each other's activities in the flood field, and that the National Association of Counties has displayed little interest in flood issues (Platt, 1987a; Platt, undated).

- **Conservation Districts.** "Conservation districts" are another type of regional entity involved with floodplain management. These districts are known by different names in different states, including Conservation Districts, Soil and Water Conservation Districts, and Natural Resource Districts.

  The Soil Conservation Act of 1935 (P.L. 74-46) authorized the Secretary of Agriculture to recommend creation of new units of government through state laws. Through these new laws, states were to authorize the creation of districts with the power to work with the Soil Conservation Service (SCS) to enforce proper land-use practices primarily to control erosion and sedimentation. The SCS developed model legislation, and over the next several years, every state proceeded to enact legislation authorizing conservation districts as a subdivision of state government. Nearly 3,000 districts, most formed on the basis of county boundaries, now cover more than 97% of the country (Sampson, 1985).

  The comprehensive resource planning and enforcement function originally envisioned for conservation districts was not realized. District programs focus on the control of soil erosion and water pollution. The most common service provided to landowners by conservation districts is conservation planning and technical assistance for individual land users and owners.

  Where state legislation permits, conservation districts also generally serve as the local sponsors for watershed management projects implemented under the Watershed Protection and Flood Prevention Act of 1954 (P.L. 566). This Act authorized the SCS to participate in comprehensive watershed management projects in cooperation with states and their subdivisions. Eligible projects were limited to watersheds of less than 250,000 acres and flood control structures of less than 12,500 acre feet of storage capacity (Stembridge, undated). P.L. 566 has since been amended to permit multiple purpose reservoirs to store up to 25,000 acre feet.

PRIVATE SECTOR ACTIVITIES

The private sector also plays important roles in flood loss reduction efforts. Typically, the various groups within the private sector work with or for government agencies at all levels to research, develop and implement flood loss reduction activities.

Academic Institutions

The role of academic institutions in flood loss reduction efforts has not changed greatly over the past 25 years. For the most part, academic institutions undertake basic and applied research and provide educational opportunities. The Water Resources Act of 1964 (P.L. 88-379) authorized the establishment of a Water Resources Research Institute within each state. These institutes have contributed significantly to research on many flood-related topics.

Several universities have taken on specific roles to disseminate hazards information and sponsor hazards- and disaster-related research. Other institutions have provided support for numerous individuals who have specialized in natural hazards and emergency management research. No academic institution, however, is known to offer a program of study specializing in floodplain management as described in *A Unified National Program for Floodplain Management.* Table 7-1 provides a list of academic institutions engaged in various aspects of natural hazards and emergency management research and education.

Nonprofit and Professional Organizations

There has been a tremendous increase in the number of nonprofit and professional organizations that have some involvement or interest in flood loss reduction. Several professional organizations have formed (or have created special interest groups) to address flood loss reduction in general or some component of flood loss reduction. These groups typically draw their membership from government agencies, academic institutions, and consulting/contracting companies. Many also welcome as members any interested individuals, while some — particularly associations of licensed professionals — have a much more restricted membership. These organizations tend to be national in scope (many also have state or regional chapters) and they accomplish their objectives through some combination of: national and regional meetings; publications, including symposium/conference proceedings, journals and newsletters; lobbying with federal and state governments; and fostering communication among the membership. Table 7-2 lists selected professional organizations currently active to some degree in flood loss reduction efforts. Many of these organizations have had a major influence on national and state policy and legislation.

Table 7-1. Academic Institutions Engaged in Natural Hazards and Emergency Management Research and Education.

Arizona State University, Office of Hazard Studies
School of Public Affairs, Tempe, AZ 85257
Joanne Nigg, Director, (602) 965-4505

Baptist College, Earthquake Education Center
P.O. Box 1009, Charleston, SC 29411
Joyce Bagwell, (803) 797-4028

Brown University, Alan Shawn Feinstein World Hunger Program
P.O. Box 1931, Providence, RI 02912
Robert W. Kates, Director (401) 863-2700

Clark University, Center for Technology, Environment, and Development (Center)
Worcester, MA 01610, Jeanne Kasperson, Research Librarian, (617) 793-7133

Colorado State University, Hazards Assessment Laboratory
204 Aylesworth Hall, Fort Collines, CO 80523
Dennis Mileti, Director, (303) 491-5951

Cornell University, Cornell Institute for Social and Economic Research/Program in Urban and Regional Studies
Natural Disasters Project, 106 West Sibley Hall, Cornell University, Ithaca, NY 14853
Barclay G. Jones, Director, (607) 255-6846

Memphis State University, Center for Earthquake Research and Information
3890 Central Memphis, TN 38152
Arch Johnston, Director (901) 678-2007

New York Medical College, Center for Psychological Response in Disaster Emergencies (PRIDE)
Valhall, NY 10595
Michael Blumenfield, Director, (901) 678-2007

New York University, Industrial Crisis Institute
649 East 19th Street, Brooklyn, NY 11230
Paul Shrivastava, Director, (718) 859-3435

State University of New York at Buffalo, National Center for Earthquake Engineering Research
Red Jacket Quadrangle, Buffalo, NY 14261, Dr. Robert Ketter, Executive Director, (716) 636-3391, 342 Capen Hall, SUNY-Buffalo, Buffalo, NY 14260, Patricia Coty, Manager for Information Services, (716) 636-3377

Texas A & M University, Hazard Reduction and Recovery Center
College of Architecture, Texas A & M University, College Station, TX 77843-3137
Dennis Wenger, Director (409) 845-7813

Texas Tech University, Institute for Disaster Research, Wind Engineering Research Center
P.O. Box 4089, Lubbock, TX 79409
James R. McDonald, Director (806) 742-3476

University of Arizona, Office of Arid Lands Studies (OALS), and Arid Lands Information Center (ALIC)
College of Agriculture, 845 North Park Avenue, Tucson, AZ 85719
Robert Varady, Manager, (602) 621-7897

University of California, National Information Service for Earthquake Engineering
Earthquake Engineering Research Center, 404 Davis Hall, Berkeley, CA 94720
Jeanette Zerneke, (415) 642-8718

University of California, California Earthquake Education Project and Chemical Education for Public Understanding Project
Lawrence Hall of Science, Berkeley, CA 94720
Herbert Thier, Director, (415) 642-8718

University of Central Florida, Florida Sinkhole Research Institute
University of Central Florida, Orlando, FL 32826
Barry Beck, Director, (407) 281-5644

University of Colorado, Natural Hazards Reseach and Applications Information Center (NHRAIC), Institute of Behavioral Science
IBS #6, Campus Box 482, University of Colorado, Boulder, CO 80309-0482
Dave Morton, Librarian, (303) 492-6818

University of Colorado, U.S. World Data Center for Glaciology, National Snow and Ice Data Center
Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado, Campus Box 449, Boulder, CO 80309-0449 Anne Brennan, Professional Research Assistant, (303) 492-1846

University of Delaware, Disaster Research Center
Newark, DE 19716
Marge Simmons, Office Coordinator, (302) 451-6618

University of Hawaii, Pacific Islands Development Program, Disaster Preparedness and Rehabilitation Project
East-West Center, 1777 East-West Road, Honolulu, HI 96848
Charles Lepani, Director, (808) 944-7745

University of Maryland-Baltimore County, Emergency Health Services Program
Baltimore, MD 21228, James Eastham, Department Chairman, (301) 455-3223

University of Massachusetts, Land and Water Policy Center
Department of Geology and Geography, Amherst, MA 010003
Rutherford Platt, Director, (413) 545-2499

University of North Carolina, Center for Urban and Regional Studies
Campus Box 3410, Chapel Hill, NC 27599-3410
Raymond J. Burby, (919) 962-3074

University of North Texas, Emergency Administration and Planning Degree Program
School of Community Service, P.O. Box 13438, Denton, TX 76203
Robert R. Reed, Director, (215) 898-4589

University of Pennsylvania, The Wharton School, Risk and Decision Processes Center
Philadelphia, PA 19104
Howard Kunreuther, Director, (215) 898-4589

University of Pittsburgh, Center for Social and Urban Research
1617 Cathedral of Learning, Pittsburgh, PA 15260
Jeanette Trauth, Association Director, Risk and Emergency Management Program, (412) 624-5442

University of Wisconsin-Extension, Disaster Management Center
Department of Engineering Professional Development, 432 North Lake Street, Madison, WI 53706 Don Schramm, Director, (608) 262-2061

Source: Natural Hazards Research and Applications Information Center. "Information Service." Natural Hazards Observer, 13, No. 3, January, 1989.

Table 7-2. Selected Professional and Nonprofit Organizations Active in Flood Loss Reduction Efforts.

American Institute of Architects (AIA)

American Planning Association (APA)

American Rivers Conservation Council

American Society of Civil Engineers (ASCE)

American Water Resources Association (AWRA)

Association of Conservation Engineers

Association of State Dam Safety Officials (ASDSO)

Association of State Floodplain Managers (ASFPM)

Association of State River Managers

Association of State Wetland Managers (ASWM)

The Coastal Society

Coastal States Organization (CSO)

The Conservation Foundation (CF)

Council of State Governments (CSG)

Emergency Managers Association (EMA)

Environmental Defense Fund (EDF)

Environmental Law Institute (ELI)

Environmental Policy Center

Friends of the River, Inc.

Interstate Council on Water Policy

National Association of Conservation Districts (NACD)

National Association of Counties

National Association of Flood and Stormwater Management Agencies

National Association of Home Builders (NAHB)

National Association of State Conservation Agencies

National Association of State Recreation Planners

National Audubon Society (NAS)

National Hazards Research and Applications Information Center (NHRAIC)

National League of Cities

National Organization for River Sports

National Recreation and Parks Association

Natural Resources Defense Council, Inc. (NRDC)

National Trails Coalition

National Waterways Technical Council

National Water Resources Association

National Wildlife Federation

The Natural Areas Association (NAA)

The River Conservation Fund

Sierra Club

The Trust for Public Land

Urban Land Institute (ULI)

Wetlands for Wildlife

An even larger group of private conservation and/or watershed organizations play an important role in water resources and floodplain management. These organizations are usually nonprofit organizations and have a broad public membership base. Most participate in various forms of public action to promote their goals and objectives and educate the public. Many are more directly involved in environmental issues related to the natural values of floodplains, but they also have concerns with regard to flood loss reduction. While several of these organizations operate nationally, many more function at a state, regional, community, and watershed level. Table 7-3 provides a representative list of these types of organizations.

The most common characteristic of these citizen-based groups is their public educational function. The organizations are typically unaffected by partisan politics, can conduct effective public forums on controversial issues, and may be able to respond to an issue more rapidly than government agencies. A common limitation faced by these organizations, however, is lack of reliable funding (Blunt, 1985).

Individuals and Corporations

The role of individuals and for-profit corporations in flood loss reduction efforts has also expanded since the 1960s. As flood loss reduction activities have increased, the opportunities for private sector involvement have also grown, and numerous individuals and companies have contributed significantly to the identification, development, and use of some of the major new activities and tools in use today. Examples include floodproofing techniques and materials, automated flood warning systems, geographic information systems, remote sensing techniques, and computerized information management.

THE FRAMEWORK FOR MANAGING FLOODPLAIN NATURAL RESOURCES

As described in Chapter 2, the natural and cultural resources of floodplains are many and diverse, and include functions related to natural flood storage and conveyance, water quality maintenance, ground-water recharge, wetlands, fish and wildlife, recreation, and forestry and agriculture, among others. Perhaps with the exception of natural flood storage and conveyance, none of the natural and cultural resources of floodplains are exclusive to floodplains. That is, ground-water recharge, agriculture, recreation, and other floodplain functions are also found outside floodplains. Natural floodplains simply provide special or particularly favorable locations for many of these values.

As a result, federal, state and local programs to manage floodplain resources are usually not focused on the floodplain, but on a particular resource or activity that may or may not be included in the floodplain. For example, programs have been developed to protect water quality, but these programs are not focused on managing just floodplains for water quality protection. Instead, the water quality functions provided by floodplains are addressed in the context of a broader program. Floodplain management and/or protection of natural floodplain resources are typically not explicit program objectives. Consequently, it is difficult to discuss management of floodplain natural resources without also addressing the same resources in nonfloodplain areas.

Table 7-3. Selected Private Conservation and Watershed Organizations Concerned with Flood Loss Reduction and Natural Resources Protection.

American Forest Council	National Recreation and Park Association
American Land Resource Association	National Trails Council
American Littoral Society	National Trappers Association, Inc.
American Rivers	National Trust for Historic Preservation
Coastal Conservation Association	National Water Resources Association
The Coastal Society	National Waterways Conference, Inc.
Connecticut River Watershed Council, Inc.	National Wetlands Technical Council
The Conservation Foundation	National Wildlife Federation
Conservation Law Foundation of New England, Inc.	Natural Areas Association
The Environmental Law Institute	The Nature Conservancy
Environmental Policy Institute	New England Natural Resources Center
Freshwater Foundation	North American Lake Management Society
Friends of the Earth	The Oceanic Society
Friends of the River, Inc.	Saves the Dunes Council
Land Trust Alliance	Sierra Club
League of Conservation Voters	Society for Range Management
Mid-Atlantic Council of Watershed Association	Soil and Water Conservation Society
National Association of Conservation Districts	The Sounds Conservancy, Inc.
National Audubon Society	The Trust for Public Land
National Center for Urban Environmental Studies	Water Resources Association of the Delaware River Basin
National Fish and Wildlife Foundation	Wetlands for Life, Inc.
National Organization for River Sports	The Wilderness Society
National Park Foundation	Wildlife Management Institute
National Parks and Conservation Association	

Source: National Wildlife Federation. Conservation Directory 1988. 1988.

The following sections of the *Assessment Report* review the management framework for protecting floodplain natural resources from the standpoint of the broader programs and activities that directly or indirectly address those resources.

THE FEDERAL FRAMEWORK FOR MANAGING FLOODPLAIN NATURAL RESOURCES

Prior to the 1960s, a number of single-purpose federal laws and programs were established to protect various natural resources and these laws and programs indirectly addressed the protection of natural floodplain resources. For example, the creation of national parks and federal forest reserves resulted in the protection of significant areas of natural floodplains, although floodplain management or protection of floodplain natural resources were not explicit purposes. Other federal laws specifically protected wildlife habitat and open space for conservation and recreation.

The Fish and Wildlife Coordination Act of 1958 (P.L. 85-624) formalized federal recognition of the importance of wetlands as natural habitat and required that most proposed federal projects or federal permits that would affect streams or other water bodies be submitted to the U.S. Fish and Wildlife Service (FWS) for review. The Housing Act of 1961 authorized federal grants to communities for acquisition of open space for conservation, recreation, and related purposes within the context of comprehensive planning. Many of the urban renewal and public housing projects administered by the Department of Housing and Urban Development focused on the reuse of blighted areas in the floodplain. The Land and Water Conservation Fund Act of 1964 (P.L. 88-578) offered financial assistance for statewide outdoor recreation planning, as well as funds for state and local land acquisition and development.

Since the late 1960s, management of the water resources functions of floodplains has been accomplished through a multitude of federal programs for water quality and pollution control, watershed management and erosion control, and ground-water and aquifer protection. Restoration and preservation of floodplain living resources/habitat functions have been addressed in multi-objective federal programs or activities aimed at protecting inland wetlands, coastal wetlands, and barrier islands. In addition, other federal programs have been specifically directed toward the protection of habitat or living resources. Protection of cultural values has often been accomplished through federally supported open space and recreation planning and urban renewal programs, especially in older cities where early settlements occurred in the floodplain. Beginning in the 1970s, cultural resources were also addressed in several other types of programs, including waterfront redevelopment projects, historic and cultural resources protection programs, and a variety of multi-purpose open space programs (e.g., water-oriented recreation, public access, and green belt programs).

Among the most significant changes in the federal framework for managing floodplain natural resources were the creation of the Council on Environmental Quality (CEQ) and the Environmental Protection Agency (EPA) in 1970, and establishment of the Office of Ocean and Coastal Resources Management (OCRM)[4] within the National Oceanic and Atmospheric Administration (NOAA) in 1972. The number of agencies concerned with protection of floodplain natural resources and their

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[4] Originally called the Office of Coastal Zone Management (OCZM).

range of program activities is no less extensive and complex than the number of agencies and programs involved with flood loss reduction.

The following major federal actions and programs have contributed, either directly or indirectly, to protection and management of natural floodplain resources.

House Document 465

In 1966, House Document 465, *A Unified National Program for Managing Flood Losses*, signaled the beginning of a new era in the management of flood losses. The natural resources functions of floodplains, however, were not specifically addressed, although the Document did recognize the need to expand the interest in floodplain use in open space acquisition programs for conservation, recreation, and other purposes. H.D. 465 noted "the possibility that in some reaches the development of floodplains for recreation may be their most efficient use and that floodplain regulation may be an important part of a recreation program," and recommended that "Authority should be given by the Congress to include land acquisition as part of flood control plans" (Task Force on Federal Flood Control Policy, 1966).

National Environmental Policy Act

It was not until the National Environmental Policy Act (NEPA) was signed by President Nixon in 1969 and became effective on January 1, 1970 (P.L. 91-190) that the natural resources of floodplains and other natural systems were formally recognized and incorporated in the federal decision-making process. By declaring environmental quality a national goal and establishing procedures for environmental assessment of proposed federal projects and programs, NEPA provided a firm foundation for consideration of the environmental values associated with floodplains. Protection of natural floodplain resources was facilitated, in particular, through the evaluation of potential impacts of development on natural resources, including natural floodplain resources and values, and the consideration of alternative actions to floodplain use and development.

Executive Orders on Floodplains and Wetlands

The federal Executive Orders on Floodplain Management (E.O. 11988) and Wetlands Protection (E.O. 11990) issued in 1977 further specified and emphasized natural floodplain resources. E.O. 11988, which applies to all proposed actions of all federal agencies, brought together concerns for human health, safety, welfare, and property with concerns for restoring and preserving natural floodplain resources. The 1986 Unified National Program noted that "... most of the Nation's wetlands, coastal barrier islands, and marine sanctuaries are located within riverine and coastal floodplains. Thus, the Floodplain Management Order is central to these other areas of environmental values" (Federal Interagency Floodplain Management Task Force, 1966).

E.O. 11990, which established federal policy favoring the protection of wetlands and required the evaluation of impacts of proposed actions on wetlands, applies to most federal actions affecting wetlands, including federal projects, federally funded activities, and other activities licensed or regulated by federal agencies. E.O. 11990, however, is not applicable to "permits, licenses, or allocations to private parties for activities involving wetlands on nonfederal property."

A Unified National Program for Floodplain Management

Natural and beneficial resources were mentioned several times in the 1976 edition of *A Unified National Program for Flood Plain Management*, and were explicitly addressed in the 1979 revisions to that document that were prepared in response to the 1977 floodplain management and wetlands protection executive orders. The 1979 version of *A Unified National Program for Floodplain Management* described the natural resources provided by floodplains in three broad categories: 1) water resources (including natural flood storage and conveyance, water quality maintenance, and groundwater recharge); 2) living resources (habitat); and 3) cultural resources (including recreational, historic, cultural, archaeologic, education, aquaculture, agriculture, and forestry resources). The 1979 report also described two basic strategies — preservation and restoration — for protection of natural resources, along with a variety of tools available for carrying out the preservation and restoration strategies. (U.S. Water Resources Council, 1979). Chapter 14 describes how these strategies and tools have been applied to protect and manage floodplain natural resources.

Principles and Guidelines

The "Economic and Environmental Principles and Guidelines for Water and Related Land Resources for Implementation Studies," issued by the Water Resources Council in 1983, provided for consideration of floodplain natural resources in federal water resources planning. In accordance with these guidelines, the potential of the floodplain for providing natural and beneficial resources (including open space, recreation, wildlife, natural flood storage, and wetland resources) must be considered in the evaluation of alternative proposals for federal water resources projects.

Water Quality/Pollution Control

The Federal Water Pollution Control Act Amendments of 1972, the Rural Clean Water Program, and the Safe Drinking Water Act of 1974 authorized important programs that serve to protect natural floodplain resources, specifically water quality functions.

- **Federal Water Pollution Control Act Amendments (Clean Water Act).** Principal federal responsibility for water quality programs was assigned to the U.S. Environmental Protection Agency by the "Clean Water Act" of 1972 (P.L. 92-500). Several programs authorized by this Act and its amendments affect natural floodplain resources through establishment of water quality standards, provision for water quality certification, grants and loans for construction of waste treatment facilities, nonpoint source pollution control, stormwater pollution control, development of a National Estuary Program, and permits for dredge and fill activities.

Section 208 of the Clean Water Act of 1972 authorized funding for development of state plans to identify and control nonpoint sources of pollution, including erosion. The Water Quality Act of 1987 (P.L. 10-4) gave new emphasis to the nonpoint source program by authorizing implementation funds as well as additional planning funds. Section 319 of the Act established requirements for states to prepare and submit to the EPA a nonpoint source assessment report and a nonpoint source management program. Section 319 also authorized funding for implementation of these nonpoint source management programs. Additional implementation funds were authorized by Section 205 (j)(5) and Section 201 (g)(1)(b) which allow states to use up to 20 percent of their construction grant funds for implementing their approved nonpoint source management programs (referred to as the Governor's 20 Percent Discretionary Fund) (Kay, 1990).

Section 405 of the Water Quality Act of 1987 (P.L. 100-4) gave the EPA broad authorities to regulate stormwater discharges. Over the next few years, major municipalities (with population greater than 100,000) will be required to participate in an EPA permit program for stormwater discharges similar to the current wastewater discharge permit program. After October 1, 1992, the stormwater discharge program will be expanded to include industries and smaller communities. These requirements represent a significant change in the Nation's approach to stormwater as the water quality of stormwater discharge will be as important a consideration as its quantity (Meagher, 1988; Association of State and Interstate Water Pollution Control Administrators, 1986).

- **Rural Clean Water Program.** The Rural Clean Water Program, authorized by Section 35 of P.L. 95-217 and administered by the Soil Conservation Service, provides for a program of protecting water quality in rural floodplains through establishment of best management practices to control nonpoint source pollution (Buie, 1979).

- **Safe Drinking Water Act of 1974.** As authorized by the Safe Drinking Water Act of 1974 (P.L. 93-253), the EPA may designate an aquifer as a principal water supply source and require review of any project affecting the aquifer. Federal assistance to the project may be denied if the project would result in contamination of the designated water source.

Watershed Management and Erosion Control

The Soil Conservation Service has been involved in watershed management and flood prevention since it was established in 1935. Under the Small Watershed Program (the P.L. 566 Program), more than 1,350 projects have been planned since the program was established in 1954. In addition to flood prevention and watershed protection, purposes of the program include public recreation development and fish and wildlife development. As part of its general responsibilities, the SCS regularly works with local conservation districts to assist individual property owners, local municipalities, and others in controlling erosion from both rural and urban areas.

Under the Conservation Provisions of the Food Security Act of 1985 (P.L. 99-198), the SCS and local conservation districts are responsible for developing management plans for highly erodible agricultural land to ensure that erosion can be reduced to "tolerable" levels. This Act established the Conservation Reserve Program (CRP) through which farmers may receive payments to set aside highly erodible cropland for at least ten years. Also, the "Sodbuster" provisions of the Food Security Act of 1985 directed the U.S. Department of Agriculture to withhold commodity crop subsidy payments to individuals who convert rangeland to cropland without adequate provision for erosion control.

Coastal Management

Coastal management legislation and programs have had an important impact on floodplains and the protection of floodplain natural resources.

- **Coastal Zone Management Act.** The Coastal Zone Management Act (CZMA) of 1972 (P.L. 92-583) authorized federal grants to states for development and implementation of coastal management programs for water and land resources in coastal zones. When the CZMA was amended in 1980, goals for both flood loss reduction and protection of natural resources were incorporated in the coastal management goals. States were required to provide for "the management of coastal development to minimize the loss of life and property caused by improper development in flood-prone, storm surge, geological hazard, and erosion-prone areas and in areas of subsidence and saltwater intrusion, and by the destruction of natural protective features such as beaches, dunes, wetlands and barrier islands." As part of the most recent reauthorization of the CZMZ in 1990, the states were encouraged to provide for "the study and development, in any case which the Secretary considers it to be appropriate, of plans for addressing the adverse effects upon the coastal zone of land subsidence and of sea level rise..."

  Also in 1990, a new section 309, Coastal Zone Enhancements Grants, of the CZMA was established. The purpose of this section is to encourage the states to undertake improvements to their existing coastal management programs to address one or more of eight identified objectives. One of these objectives is "preventing or significantly reducing threats to life and destruction of property by eliminating development and redevelopment in high-hazard areas, managing development in other hazard areas, and anticipating and managing the effects of potential sea level rise and Great Lakes level rise." The Enhancement Grants, which are 100% federally funded, are supported by a percentage of the funds appropriated for support of the basic coastal management program.

- **Coastal Barrier Resources Act.** Concerns over past and possible future damage costs, along with environmental and public safety concerns and the realization that federal programs have historically encouraged and assisted development of barrier islands with resulting losses of natural, cultural, recreational, and other resources, led to the enactment of the Coastal Barrier Resources Act (P.L. 97-348) in 1982. The law was designed to establish a system of largely undeveloped coastal barriers along the Atlantic and Gulf coasts (totalling 656 miles of oceanfront shoreline and encompassing 454,000 acres) and to restrict federally subsidized development of those barriers (Platt, 1987b).

- **NOAA, Coastal Hazards Program.** In 1980, the National Oceanic and Atmospheric Administration established a Coastal Hazards Program to provide further assistance to coastal states for planning for and responding to coastal hazards, including hurricane, flooding, shoreline erosion, and subsidence hazards.

- **National Estuary Program.** The National Estuary Program, authorized by Section 317 of the Water Quality Act of 1987 (P.L. 100-4), provides a comprehensive planning and implementation process for nationally significant estuaries. Program goals are the protection and improvement of water quality and the enhancement of living resources. These goals are to be achieved through collaborative efforts called Comprehensive Conservation and Management Plans (CCMPs).

Wetland Protection

Wetland protection programs (both regulatory and nonregulatory) are often directly applicable to floodplain management. Wetlands are typically the most hazardous areas of floodplains — often found within the one-year or two-year floodplain — and the natural functions of wetlands (including flood storage, wave reduction, habitat and erosion control) are well-recognized. Federal responsibilities for wetland protection and management include regulatory authority (primarily through the Section 404 (of the Clean Water Act) Regulatory Program), inventories and technical assistance in wetland evaluation, and funding of wetland acquisition (either directly by federal agencies or through provision of funds for state and local acquisition). The principal federal agencies responsible for wetland protection are the Corps of Engineers, the Fish and Wildlife Service, the Soil Conservation Service, and the Environmental Protection Agency. The following federal laws are of particular significance with regard to wetland protection.

- **Water Bank Act of 1970.** The Water Bank Act of 1970 (P.L. 91-559) authorized the Water Bank Program administered by the Agricultural Stabilization and Conservation Service (ASCS) of the USDA. Under this program, wetlands along waterfowl flyways are withheld from farm use under 10-year agreements with landowners. Landowners receive annual payments to help preserve wetlands that are important breeding and nesting areas for migratory waterfowl. While waterfowl habitat protection is the primary objective, other program objectives include flood control, groundwater recharge, and pollution and sediment control.

- **Clean Water Act, 1972.** Section 404 of the Clean Water Act of 1972 (as amended) supplemented the Corps of Engineers' existing permitting program (authorized by Section 10 of the River and Harbor Act of 1899) regarding activities in traditionally navigable waters. Section 404 requires permits for the discharge of dredged or fill material into all waters of the United States. Various court decisions expanded the Corps' jurisdiction to cover all waters of the United States, including adjacent wetlands. Through this expansion of jurisdiction, the Corps' responsibilities in floodplain management were strengthened. Section 404 also authorized the EPA to prohibit or restrict discharges with unacceptable adverse impacts on fish, shellfish, wildlife, water supply or recreation. The Section 404 Program also provides for the consideration of flood conveyance, flood storage and flood damage potential in the evaluation of permit applications.

- **Food Security Act of 1985.** The "Swampbuster" provisions of the Food Security Act of 1985 rescinded a policy established in the original Swamplands Act of 1849 (applying to Louisiana) that had encouraged reclamation of wetlands. Under the Swampbuster provisions, federal agricultural subsidies, farm storage facility loans, crop insurance, and agricultural disaster payments are not to be made to individuals who convert wetlands to commodity crops after 1985 (Platt, 1987b).

The Conservation Reserve Program (CRP) authorized by the Food Security Act of 1985 focuses on the protection of highly erodible lands, but previously converted wetlands may also qualify for "set-aside" under the CRP. In addition, land may be enrolled in the CRP as a "filter strip" if it is located adjacent and parallel to: a) a continually flowing stream, creek, or river; b) a seasonal stream that flows only during a part of the year; or c) a lake or other permanent body of water, including wetlands, with a surface area of at least five acres (Soil and Water Conservation Society, undated).

- **Emergency Wetlands Resources Act of 1986.** The Emergency Wetlands Resources Act of 1986 (P.L. 99-645) includes a variety of measures to promote wetland conservation and offset or prevent wetland losses. Title II of this Act authorizes several sources of increased funding for the Migratory Bird Conservation Fund, including acquisition of migratory bird habitat and operation and maintenance of refuges. Title III amends the Land and Water Conservation Fund (LWCF) to: 1) eliminate the restriction on acquiring migratory waterfowl areas; 2) require that Statewide Comprehensive Outdoor Recreation Plans specifically address wetlands as important outdoor recreation resources; and 3) qualify wetlands as suitable replacement for LWCF lands converted to other uses. Title IV directs the Secretary of Interior to continue the National Wetlands Inventory and to update the Fish and Wildlife Service report on status and trends of wetlands and deepwater habitat. Title IV also directs the Secretary of Interior to report to Congress on the status, condition and trends of wetlands and the effects of federal programs on wetlands in specified problem areas of the United States. (Pierce, 1988).

Wild, Scenic and Recreational Rivers

The designation of certain of the Nation's rivers as "wild and scenic" serves to protect floodplain natural resources.

- **Wild and Scenic Rivers Act of 1968.** The Wild and Scenic Rivers Act of 1968 (P.L. 90-542) provided for the designation of "wild and scenic" rivers and the evaluation of federal projects that would impact the values of those designated rivers. Section 5(d) of this Act requires all federal agencies involved in "planning for the use and development of water and related land resources" to give consideration to potential national wild, scenic and recreational river areas. Section 7 of the Act prohibits the Federal Energy Regulatory Commission from licensing the construction of any dam, water conduit, reservoir, powerhouse, transmission line, or other project works on or directly affecting any component of the National Wild and Scenic Rivers System. Further, no department or agency of the United States is to assist by loan, grant, license or otherwise in the construction of any water resources project that would have a direct and adverse effect on the "wild and scenic" values of designated rivers (National Park Service, 1989).

  Under Section 11 of the Wild and Scenic Rivers Act, the National Park Service (NPS) established a State and Local River Conservation Assistance Program. The NPS offers assistance to state and communities in protecting rivers and streams throughout the country (Chester River Association, 1988).

Fish and Wildlife Protection

The U.S. Fish and Wildlife Service administers several programs to protect fish and wildlife (including rare and endangered species) and their habitat. Other agencies are involved in fish and wildlife protection through a variety of programs. Since the 1960s, protection efforts have been expanded through both legislation and an international agreement.

- **Endangered Species Act of 1973.** The Endangered Species Act of 1973 (P.L. 93-205) provides for the protection and restoration of threatened and endangered species and their critical habitats. Section 15(b) of the Act authorized the FWS to provide grants to states that have entered into cooperative agreements with the FWS to assist in the development of programs for the conservation of endangered and threatened species. Funds may be used for land acquisition, research, habitat surveys, planning, management, and public education. The FWS will normally provide up to 75 percent of eligible project costs (Office of Management and Budget, 1988).

- **North American Waterfowl Management Plan.** In 1986, United States and Canadian officials signed the North American Waterfowl Management Plan. This 15-year plan provides a framework for international cooperation to protect waterfowl habitat, restore declining waterfowl populations, and enhance research and management. Its objective is to restore North American waterfowl populations to levels prevalent in the 1970s. Among the measures called for by the plan is the restoration of over five million acres of wetlands in the United States and Canada (Groman, 1986; Collins, 1988).

Historic and Cultural Resources Preservation and Restoration

Preservation of historic resources and establishment of national landmarks began in the United States in the mid-1800s.[5] It was not until the 1960s, however, that federal efforts, supported by state and local preservation laws and activities, became integrated in a comprehensive, focused program. The National Historic Preservation Act (NHPA) of 1966 (P.L. 89-665) gave the National Park Service authority to designate privately owned cultural resources as "significant" and to provide grants for their rehabilitation. The NHPA also created the Advisory Council on Historic Preservation. In addition, the NHPA broadly defined the federal interest in historic resources to include resources of state and local value, as well as nationally significant properties. As amended, the NHPA remains the "key federal law designed to encourage identification and preservation of America's cultural resources" (Duerkson, 1983). The NPS is the agency with principal federal responsibility for historic and cultural resources.

[5] See Duerkson, 1983, for discussion of the evolution of federal efforts for historic preservation.

STATE AND COMMUNITY FRAMEWORK FOR MANAGING FLOODPLAIN NATURAL RESOURCES

At the state and local levels, numerous regulatory and nonregulatory programs have been developed that apply directly or indirectly to floodplains. These include wetland, coastal management, sand dune protection, and shoreline management programs. Many of these programs have paralleled federal efforts in resource management and environmental protection. In addition, many state and local governments have incorporated performance standards or guidelines for the protection of natural resources into zoning, subdivision, and other community regulations. The application of various techniques by state and local governments to protect and manage natural floodplain resources is described in Chapter 14.

As with many federal programs, management of floodplain natural resources is generally not an explicit objective of state and local programs, but is often accomplished incidentally with multi-purpose programs or programs directed at specific resources.

Environmental Policy

Several states have adopted environmental policy acts that provide for consideration of the impacts of proposed state and local projects on natural resources, including natural floodplain resources and values. As of 1986, thirteen states had established environmental policy acts that ranged from simple statements regarding the control of air, water and land pollution to complex documents with requirements for environmental impact statements (Cowles, 1986).

Wetland Protection

All coastal states currently have wetland protection programs (these are either separate coastal wetland programs or programs that incorporate the regulatory provisions of coastal management or shoreland management programs) (Kusler, 1982). In addition, several states have wetland mapping programs and several states have explicit inland wetland protection programs requiring permits for activities in these areas. Some inland wetland protection programs are based on direct state permitting; others on local permitting subject to state oversight or standards. Local governments have also adopted wetland permitting programs (with regulations consistent with state standards) or combined wetland protection and floodplain management ordinances.

A recent report prepared for the EPA notes that "today, many federal agencies, including the EPA, recognize that much of the progress being made in wetland protection is occurring within state and local programs" (Cowles, 1986). However, the same report discusses several inadequacies in the Nation's program for wetland protection. These inadequacies include the varying extent of regulatory jurisdiction, the different use of restrictions for different wetlands, variation in enforcement, voluntary participation in some types of programs, and state and federal laws that act to discourage wetland protection.

Coastal and Shoreline Management

All coastal and Great Lakes states with the exception of Georgia, Illinois, Indiana, Minnesota, Ohio, and Texas have adopted federally approved coastal management programs, most prepared in response to the federal CZMA. Georgia and Minnesota have coastal regulatory programs, but not federally approved coastal management programs. Coastal management programs in California and Oregon predate the federally supported effort.

Through their coastal management programs, the states have adopted a great variety of measures that directly or indirectly address coastal floodplains and natural resources. Some have adopted comprehensive legislation that includes various provisions for restoration and preservation of living resources, natural areas, floodplains, and other resources. Other examples of measures include: beach and sand dune protection plans, ordinances, and regulations; wetland mapping and regulatory standards; use standards for critical areas; designation of areas for preservation/restoration; and site plan reviews for development in coastal areas. At the local level, some communities have developed coastal management programs consistent with a state-established management framework. Some state programs provide for local application of state controls.

As of 1982, six states (Maine, Michigan, Minnesota, Vermont, Washington, and Wisconsin) had enacted special legislation for protection and management of shoreline areas and had established state standards for local regulation (Kusler, 1982). This kind of legislation generally establishes multiple goals for shoreline areas, including goals for the protection of wildlife, protection of sensitive shoreland areas (beaches, sand dunes), and erosion control.

At the local level, regulations (many of which include flood hazard provisions) have been adopted by many communities. Many local zoning and subdivision regulations, for example, include provisions related to protection of natural floodplain resources, such as shoreline setback provisions, density limits in shoreland areas, and specification of uses compatible with natural resources protection.

Other Resource Protection Programs

A 1982 report prepared for the Water Resources Council (Kusler, 1982) included the following descriptions of the extent to which state and local resource protection/management programs and floodplain management and regulatory programs addressed floodplain natural resources.

- FLOOD CONVEYANCE: "Protection of flood conveyance was a common objective of shoreland, wild and scenic river, wetland regulatory, and floodplain management programs in the 1970s. Many of these programs were designed to protect the entire natural or 'no-rise' floodway."
- FLOOD STORAGE: "Protection of flood storage was an objective of most inland and local wetland programs and some shoreland zoning and wild and scenic river programs. Some localities also adopted floodplain or stormwater management regulations to protect storage."
- WILDLIFE HABITAT: "Most state coastal and inland wetland regulation and acquisition programs and the Federal 404 permit program are designed, in part, to protect duck nesting and fish spawning grounds. However, state and federal floodplain management regulations rarely

emphasize wildlife protection as an objective, although they may incidentally achieve this result by limiting alteration of habitat."

- POLLUTION CONTROL: "Federal, state, and local wetland, shoreland zoning, coastal zone management, and wild and scenic river programs are designed, in part, to prevent pollution by providing setbacks and maintaining vegetation ... Although pollution control is often a stated objective of floodplain regulations, regulation of shoreland vegetation removal and control of subtle sources of pollution is rare."

- NATURAL CROPS, AGRICULTURE AND FORESTRY: "Some wetland and coastal zone management programs are designed in part to protect natural crops. Floodplain regulatory programs rarely address this issue ... Measures to preserve prime agricultural lands and shape urban growth have been taken in California, Hawaii, Maryland, Massachusetts, New Jersey, and Oregon ... Some wetland and forest protection programs regulate excessive cutting in forest areas."

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

- RECREATION, CULTURAL AND HISTORIC RESOURCES: "In many areas of the country, states and localities have acquired floodplains to serve fishing, hunting, bird watching, picnicking, hiking, jogging, swimming and boating areas ... Boston, Austin and Tulsa ... have focused their major urban renewal and historical preservation and restoration projects on waterfront areas ... Floodplain regulations protect recreation and cultural values by limiting development densities and encouraging such private recreational uses as golf courses, picnic areas, and playing fields."

States and communities have also adopted several other types of resource management programs that indirectly contribute to management of natural floodplain resources. For example, Wild and Scenic Rivers or River Corridor Programs have been adopted in several states, including California, Michigan, Minnesota, New York, and Oregon. In addition, states have a variety of laws and regulations that limit the removal of trees along streams to protect esthetics, water temperature, and fish habitat. Thirty two states have established Streamside Management Area best management practices for timber harvest near streams (Essig, 1991).

Stormwater management has traditionally been a local concern, with only limited state and federal government involvement. Stormwater management is now taking on more importance at the local level and receiving increased attention from state and federal governments. Many urban communities have begun to recognize that areas devoted to stormwater management represent a significant portion of their open space land and opportunities for urban recreation and wildlife protection. In addition, the cost to communities of damages caused by stormwater flooding and investment in costly channelization and other conduits can sometimes be reduced through different approaches to stormwater management. A nationwide survey of communities in 1983 showed that only 39% had stormwater regulations in effect (Burby, 1985).

Counties, special districts, and conservation districts as previously described are also active in managing natural resources. Within the last few years, several stormwater management utilities have been organized as special districts.

PRIVATE SECTOR ACTIVITIES FOR MANAGING FLOODPLAIN NATURAL RESOURCES

The role of the private sector in protecting natural floodplain resources is similar to the private sector role for flood loss reduction. Academic institutions, professional and nonprofit groups, and for-profit organizations have all made important contributions to the preservation and restoration of floodplain natural resources.

The role of national and local land trusts and similar organizations is particularly significant. Over 700 of these organizations exist throughout the Nation. Most are incorporated as nonprofit organizations so that they may receive donations, including donations of land, that provide tax benefits for donors. Typically, land trusts are created to receive and manage land as open space or for historic purposes. Many target particular types of land for acquisition, frequently including wetlands, floodplains, and unique habitat areas.

The private sector, particularly academic institutions and corporate entities, has also contributed importantly to wetland creation and restoration/enhancement efforts.

THE UNITED NATIONS INTERNATIONAL DECADE FOR NATURAL DISASTER REDUCTION

In 1987, the United Nations' General Assembly passed resolution No. 42-169 and declared 1990 to 2000 A.D. as the International Decade for Natural Disaster Reduction (IDNDR). The UN's goal during the IDNDR is to take concerted action to reduce loss of life and property and to minimize the social and economic disruption of natural disasters. The UN urged each member country to develop a national program for the IDNDR.

In 1989, the Committee on Earth and Environmental Sciences of the President's Office of Science and Technology Policy formally established the Interagency Subcommittee on Natural Disaster Reduction. The Subcommittee's goal is to develop a comprehensive U.S. plan for reducing natural disasters. It is anticipated that this *Assessment Report* will provide useful input to the United States' program for the IDNDR.

SUMMARY AND CONCLUSIONS

The extent and manner to which floodplain management is conducted at each level of government is highly dependent on authorizing legislation and the agencies given responsibility for carrying out legislative mandates. The management framework for flood loss reduction does not exist as a separate, easily identifiable set of legislative and policy directives. In many cases flood loss reduction initiatives are included within a larger program effort — within water resources management, emergency management, environmental protection, and community development and redevelopment programs, for example. Similarly, the management framework for protection of floodplain natural resources can not be described as a separate, cohesive set of actions. Instead, efforts to protect floodplain natural resources are part of broader resource protection programs that address, sometimes only incidentally, the natural resources associated with floodplains.

Despite the difficulty of precisely describing the management framework for floodplain management, it is clear that this framework has changed and expanded significantly since the 1960s. Some of these changes — notably the National Flood Insurance Program — have been the direct result of initiatives to implement a recommendation of House Document 465 —*A Unified National Program for Managing Flood Losses*. Others, such as the Executive Order on floodplain management, and incorporation into the Unified National Program of goals to restore and preserve floodplain natural resources, have resulted from actions of the Federal Interagency Floodplain Management Task Force. Still others, such as recent changes to the NFIP to provide for flood insurance payments to structures in imminent danger of collapse due to erosion and changes to disaster assistance legislation to provide funds for mitigation, have been strongly influenced by the efforts of state and local governments and by professional organizations. Many more changes have occurred as a result of other, less easily identifiable factors, such as grassroots support for environmental protection and pollution control programs.

Whatever the mechanisms leading to change, a major strengthening of the framework for floodplain management has been accomplished at all levels of government. Reduction of flood losses is now less dependent on flood control works and federal actions. While the federal government has been and remains a strong force behind efforts to reduce flood losses and protect natural floodplain resources, a major shift has occurred toward an essential partnership among federal, state and local governments. A shift has also occurred toward a combined program of structural and nonstructural approaches to floodplain management. Full coordination of the many separate programs that now form the expanded framework for floodplain management has yet to be achieved, however, within and between the different levels of government that are involved.

CHAPTER 8:

REGULATORY AND DESIGN STANDARDS

A national standard is necessary, and the 100-year standard is reasonable and widely used. All states that have adopted a standard use the 100-year standard. About 17,000 communities in the nation use the standard in their local floodplain management regulations.

Association of State Floodplain Managers, 1983

Standards provide a means for uniform application and review of design, construction and regulatory practices. By examining the degree to which standards have been adopted and complied with, a limited measure of the effectiveness of program implementation can be determined. Two types of standards are generally employed — prescriptive standards and performance standards — and both are utilized for floodplain management purposes. A prescriptive standard sets some clearly identified limits, such as the minimum height a building must be elevated above flood waters. A performance standard generally requires that some goal be achieved, but allows for flexibility in how that goal may be attained. A requirement that buildings be designed and constructed so as to withstand the forces exerted by floodwater is an example of a performance standard.

When a Unified National Program for Floodplain Management was first proposed in 1968, few nationwide standards for floodplain management existed. During the past 20 years, some of the standards that were in use in the mid-1960s have changed and additional standards have emerged. Several nationwide standards are now in place that apply directly to floodplain management for loss reduction or the protection of natural resources. Many other standards indirectly influence floodplain management, particularly standards pertaining to natural resources protection.

Nationwide standards are typically established by federal agencies as part of program regulations, or sometimes directly by Congress. These standards may be mandatory or required only if there is participation in a voluntary federal program. Federal agencies commonly establish some minimum standard with which state or local governments must comply. Generally, the state and local governments are then free to impose a more stringent standard within their jurisdictions. They may not, however, adopt a standard that is less restrictive than the federally established minimum standard.

FLOOD LOSS REDUCTION STANDARDS

Most floodplain management standards aimed at reducing flood losses relate in some manner to the frequency, depth or extent of flooding that can be predicted at a particular location, or to the placement of structures or other obstructions within a regulated floodplain. Most of the nationwide standards for flood loss reduction are derived from the minimum floodplain management criteria of the National Flood Insurance Program (NFIP).

ONE PERCENT ANNUAL CHANCE ("100-YEAR") FLOOD AND FLOODPLAIN

The one percent annual chance flood[1] and floodplain have been widely adopted as a common design and regulatory standard in the United States. Prior to recognition of the one percent annual chance standard, several other standards existed. Early standards for the design of engineering works to reduce flood losses included the "maximum probable flood" adopted by the Tennessee Valley Authority (TVA) and the "standard project flood" adopted by the Corps of Engineers (Corps). In addition, shortly after the TVA initiated its floodplain management assistance program in 1953, it began promoting the use of a "regional flood" standard (based on a flood comparable in magnitude to the largest known floods on similar streams within approximately 60 to 100 miles) for local flood damage prevention planning. In the 1960s, the Corps adopted an "Intermediate Regional Flood" (one percent frequency) flood level as its nonstructural standard. In the 1950s, the Soil Conservation Service (SCS) adopted a "25-year" (four percent annual chance) flood level as its standard for use in agricultural flood hazard areas and a one percent flood level for urbanized areas. Several states also enacted floodplain encroachment laws incorporating different standards, including the one percent annual chance flood (Federal Emergency Management Agency, 1983).

The move toward a national program of flood insurance in the mid-1960s provided the major impetus for developing a uniform national standard. In order to provide an effective flood insurance program, an accurate assessment of risk based on a reasonable standard was essential. As part of its process of developing regulations for the NFIP, the Department of Housing and Urban Development (HUD) convened a group of experts to provide advice on a regulatory standard. This group recommended adoption of the one percent flood for determining acceptable risk, and that standard was incorporated into the NFIP regulations and subsequently specified by Congress in the 1974 amendments to the NFIP[2]. As thousands of communities began to participate in the NFIP, the one percent annual chance flood standard came into common use.

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1 The one percent annual chance flood is also known as the "100-year" flood and the base flood. Since the "100-year" flood is a statistical probability, flood levels of this magnitude may occur with a greater or lesser frequency than once every 100 years, and may occur even in successive years. There is a 26 percent chance of a "100-year" flood occurring at some point during the life of a 30-year mortgage. Chapter 9 describes some of the confusion generated by "one percent annual chance flood," "100-year flood," and other terminology used to express the same concept.

2 The "100-year" floodplain is designated as Special Flood Hazard Areas on maps prepared by the Federal Insurance Administration (e.g., all A and V zones on Flood Insurance Rate Maps). Further discussion is provided in chapters 11 and 13.

Most states have now enacted state legislation specifying the one percent flood as a standard. Those states without specific legislation support the use of a one percent standard on a community-by-community basis (Federal Emergency Management Agency, 1983).

The one percent annual chance flood was formally established as a standard for use by federal agencies with the issuance of Executive Order 11988 (the Floodplain Management Executive Order) in 1977. At the request of the Office of Management and Budget (OMB), the Federal Emergency Management Agency (FEMA) reviewed the appropriateness of the one percent annual chance flood standard in 1982 (Federal Emergency Management Agency, 1983). FEMA concluded that:

1) The one percent flood standard is strongly supported and being applied successfully by all levels of government.

2) No alternatives have been identified that are superior to the one percent flood standard, and there is no evidence to justify the expenditure of funds that would be necessary to convert to another standard.

3) The review revealed areas in which improvements or refinements in application of the one percent flood standard to unique flooding situations could further affect flood loss reduction.

FEMA then made the following recommendations:

1) The one percent flood standard should be retained.

2) The federal agencies should be advised that the one percent flood standard is appropriate and should continue to be utilized as the minimum standard in flood hazard reduction actions.

3) FEMA should take the lead in evaluating mitigating measures that can be applied to reduce flood losses in unique situations such as alluvial fans and headwater flooding, and to develop the technical methods of applying the one percent flood standard to these problem areas.

OTHER FLOOD FREQUENCY STANDARDS

Although the one percent annual chance flood has been adopted as the primary standard for floodplain management, other standards, including those established by the "Economic and Environmental Principles and Guidelines for Water and Related Land Resources for Implementation Studies," may apply in certain situations. In the interest of safety, some agencies have adopted more stringent standards, several of which are described here.

"Economic and Environmental Principles and Guidelines"

In March 1983, the Water Resources Council (WRC) issued the "Economic and Environmental Principles and Guidelines for Water and Related Land Resources for Implementation Studies." These Principles and Guidelines provide guidance to federal water resource agencies for maximizing net returns when formulating project proposals. In accordance with the Principles and Guidelines, maximum net returns using the "National Economic Development" (NED) account should be evaluated to optimize and proportion proposed water and related land resources projects. With regard to flood prevention projects, this may mean designing a level of protection based on a standard different than the one percent annual chance flood used in the NFIP. If a level of protection other than the optimum established by the NED account is to be provided, the federal agency should justify the selected level of protection with respect to social impacts, environmental improvements, or regional development considerations. Since 1983, projects have been formulated to reflect various levels of protection depending on flood damage, economic conditions, and physical settings.

Individual measures are designed to meet the agencies' engineering and other safety criteria. Where a system of measures is needed to provide for an overall flood control program, however, the total system should be optimized in accordance with the Principles and Guidelines to maximize net returns.

Two-tenths Percent Annual Chance ("500-Year") Flood and Floodplain

The WRC's Floodplain Management Guidelines (U.S. Water Resources Council, 1978) for implementing Executive Order 11988 (Floodplain Management) call for federal agencies to apply a "500-year" flood[3] (0.2 percent flood) standard to the location of "critical activities." Critical activities may include health care facilities such as hospitals and nursing homes, emergency service facilities, and areas for the storage of hazardous materials.

Standard Project Flood and Probable Maximum Flood

It may be appropriate to apply a very large (low frequency) design flood standard to the design of major flood control structures, especially if the failure of those structures could result in massive damage or great loss of life. These large design floods are usually referred to as a Standard Project Flood (SPF) or a Probable Maximum Flood (PMF). Neither the SPF nor the PMF are equivalent to a specific return flood frequency. The SPF represents the most severe combination of meteorological and hydrological conditions considered "reasonably characteristic" of a particular region (U.S. Army Corps of Engineers, 1982), while the PMF is "The flood magnitude that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible..." in a region (U.S. Army Corps of Engineers, 1979).

Least-Cost Design Flood

The Federal Highway Administration (FHWA) and many states use a least-cost analysis for the design of many roads and bridges. A least-cost analysis takes into account the total costs, including flood damage costs, over the projected life of the structure. A final design may withstand a flood event greater or less than a one percent annual chance flood depending on the conditions at a particular site (Federal Highway Administration, 1980).

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[3] The area affected by a "500-year" flood is shown on FIA flood hazard maps as Zone B or, on more recent maps, as Zone X.

REGULATORY FLOODWAY

The "regulatory floodway" concept evolved from work of the Corps of Engineers and the TVA to address the needs of floodprone communities and guide development in growing communities with undeveloped floodplains. The concept was later incorporated into the NFIP. In areas where sufficient data have been developed, communities participating in the NFIP are now required to adopt a regulatory floodway within the designated one percent floodplain.

The area delineated as the regulatory floodway is the area that will carry the waters of a particular magnitude flood without increasing the water surface elevation more than a designated level. Areas outside the regulatory floodway but still within the designated one percent floodplain are referred to as the "flood fringe." In delineating a floodway, it is assumed that the flood fringe areas will be fully developed and completely obstruct floodwater. The regulatory floodway will then serve to convey the floodwater.

Federal Insurance Administration (FIA) minimum regulations require that the regulatory floodway be delineated so that it can pass the one percent annual chance flood without increasing the water surface elevation within the regulatory floodway by more than one foot at any point. Several states and communities have adopted more stringent requirements for the regulatory floodway by limiting the increase in water surface elevation to less than one foot, generally resulting in a wider floodway. For example, Minnesota and Montana limit the rise to .5 foot, New Jersey to .2 foot, Illinois and Indiana to .1 foot, Wisconsin to .01 foot, and Massachusetts permits no increase in water levels within the floodway. Several states permit a variable rise (up to 1 foot) depending on the potential impact to existing development (Association of State Floodplain Managers, 1988).

Floodway boundaries are determined by application of hydraulic modelling techniques. A hydraulic model is developed to reflect existing conditions, and the model is manipulated to reduce the area in the flood fringe until the water surface within the floodway rises a foot or less. In general, the modeled flood conveyance is removed equally from both edges of the floodplain, but exceptions to this practice are permitted.

Encroachments Within the Regulatory Floodway

FIA minimum regulations also prohibit encroachments[4] within the adopted regulatory floodway that would result in any increase in flood levels (above the one-foot rise already allowed) during a one percent annual chance flood. Some states have adopted more stringent standards through absolute prohibition of certain structures in the floodway. For example, Montana and Wisconsin do not allow any new buildings in the floodway, and Indiana, Michigan and Washington do not allow new residential buildings in the floodway (Association of State Floodplain Managers, 1988).

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[4] Encroachments include fill, new construction, substantial improvements, and other development.

REGULATING AN ALLOWABLE RISE IN FLOOD LEVELS

In floodplains where a regulatory floodway has not been designated, FIA minimum regulations require that no development be permitted within the one percent annual chance floodplain that would — individually or cumulatively with other anticipated development — increase the water surface elevation of the base flood by more than one foot.

COASTAL FLOOD STANDARDS

Important standards in coastal flood hazard areas pertain to designation of velocity zones and determination of the one percent annual chance flood elevation.

Coastal Velocity Zone

In coastal areas, NFIP regulations establish a V-zone (Velocity zone) to indicate areas subject to the effects of high velocity waters and damaging wave action during a one percent annual chance flood. The extent of the V-zone is based on calculations of how far inland the storm surge can support a three-foot wave. Where wave height decreases below three feet, the V-zone terminates. The three-foot wave height standard was adopted based on research conducted by the Galveston District of the Corps of Engineers (U.S. Army Corps of Engineers, 1975) that determined a wave height of three feet or greater was likely to cause structural damage to buildings, and that waves of lesser height generally did not cause structural damage.

One Percent Annual Chance Flood Elevation in Coastal Areas

Initial NFIP flood hazard maps of coastal areas showed one percent annual chance flood elevations based on "still-water" elevations. (The still-water elevation is calculated based on the effects of astronomical tides and storm surge conditions, but does not include the added effects of waves on top of the still-water elevation.) In 1977, the National Academy of Sciences (NAS) concluded a review of the feasibility and methods for calculating wave action associated with storm surges (National Academy of Sciences, 1977). Following the recommendations of the NAS report, the FIA began to incorporate wave heights into Flood Insurance Studies (FISs), and began to define the one percent annual chance flood elevation in coastal areas as synonymous with the estimated wave crest elevation.

STANDARDS FOR THE ELEVATION OF STRUCTURES

Minimum NFIP criteria for the elevation of structures distinguish between residential and non-residential structures. For residential structures, new construction and substantial improvements within the one percent annual chance floodplain must have the lowest floor — including any basement — elevated to or above the one percent annual chance flood level[5]. For nonresidential structures, the option of elevating the lowest floor — including basement — to or above the one percent annual chance flood level is provided. Also, nonresidential structures "together with attendant utility and sanitary facilities, [may] be designed so that below the base flood level the structure is watertight with walls substantially impermeable to the passage of water, and with structural components having the capability of resisting hydrostatic and hydrodynamic loads and effects of buoyancy" (Federal Emergency Management Agency, 1986).

Eighteen states and hundreds of communities have established more stringent standards than imposed by the NFIP. Many jurisdictions, for example, require some or all structures to have the lowest floor (including the basement) elevated at least one foot above the one percent annual chance flood level. Other jurisdictions require even greater elevation above the one percent annual chance flood level. These more stringent standards may apply to all buildings in the floodplain or to only certain types of buildings. For example, Pennsylvania state law requires new jails, hospitals, nursing homes, mobile home parks, and hazardous materials facilities to be 1.5 feet higher than the base flood elevation. Some coastal communities in Florida require freeboards of four, six, and even eight feet. Arizona requires all new and replacement mobile homes to have the lowest structural member elevated one foot above the one percent annual chance flood elevation (Association of State Floodplain Managers, 1988).

DEFINING "SUBSTANTIAL DAMAGE" AND "SUBSTANTIAL IMPROVEMENT"

Substantial damage to a structure and substantial improvement of a structure relate to the amount of damage that may be sustained or to improvements that may be made before certain regulatory and flood insurance requirements are triggered. NFIP regulations (44 FR, § 59.1) define substantial improvement as:

> *any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure before the 'start of construction' of the improvement. This term includes structures which have incurred 'substantial damage', regardless of the value of or actual cost of repair work performed. The term does not, however, include either (1) any project for improvement of structure to correct existing violations of state or local health, sanitary, or safety code specifications which have been identified by the local code enforcement official and which are the minimum necessary to assure safe living conditions or (2) any alteration of a 'historic structure', provided that the alteration will not preclude the structure's continued designation as a 'historic structure'* (Federal Emergency Management Agency, 1989a).

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[5] Communities may request an exception to allow dry floodproofed basements below the "100-year" base flood level. See Chapter 13 for additional information.

As defined in § 59.1 of the NFIP regulations, a building is considered to be substantially damaged when:

> *damage of any origin is sustained by a structure whereby the cost of restoring the structure to its before damaged condition would equal or exceed 50 percent of the market value of the structure before the damage occurred.*

Any work performed on structures determined to be substantially damaged is automatically considered to be a substantial improvement, regardless of the actual repair work performed.

The Federal Emergency Management Agency notes that the market value threshold of 50% was chosen as a compromise between the extremes of: 1) prohibiting all investment in structures that do not meet minimum NFIP floodplain management requirements in flood hazard areas; and 2) allowing structures to be improved in any fashion without regard to the hazard present. The 50% threshold conforms with similar thresholds included in building codes and zoning regulations (Federal Emergency Management Agency, 1989b).

A few states and some communities have substantial improvement regulations that differ from the 50% standard established by the NFIP. For example, Indiana uses 40% (Association of State Floodplain Managers, 1988), and some communities have reportedly adopted standards with an even lower percentage threshold (Riebau, 1988).

PERFORMANCE STANDARDS FOR ACTIVITIES IN FLOOD HAZARD AREAS

Performance standards for floodplain management are in widespread use and are included in land use regulations required by the NFIP and elsewhere. Performance standards may be applied alone or in combination with a prescriptive standard. Perhaps the most widely applicable performance standards relate to floodproofing of structures.

Floodproofing In Riverine Areas

As described previously (see the previous section on Standards for the Elevation of Structures), existing NFIP requirements for construction of nonresidential structures require that a structure be elevated to or above the one percent annual chance flood level or be designed to resist flood damages. This requirement provides the developer with an option of meeting a specific prescriptive standard (elevation) or performance standard (resistance to effects of flooding). Rather than specifying particular designs and materials, the regulations allow the designer flexibility in selecting ways to resist the effects of flooding.

Floodproofing In Coastal Zones

Similarly, NFIP criteria (44 FR, § 60.3(e)(4)) require that structures located in V-zones be:

> *... elevated on pilings and columns so that (i) the bottom of the lowest horizontal structural member of the lowest floor ... is elevated to or above the base flood level; and (ii) the pile or column foundation and structure attached thereto is anchored to resist flotation, collapse and lateral movement due to the effects of wind and water loads acting simultaneously on all building components. Water loading values used shall be those associated with the base flood. Wind loading values used shall be those required by applicable State or local building standards* (Federal Emergency Management Agency, 1989a).

NFIP regulations prohibit the use of fill for structural support of buildings within V-zones. Also, a combination of specific standards and performance standards apply to the construction of breakaway walls in V-zones. Current NFIP regulations permit the space below an elevated structure to be constructed with nonsupporting breakaway walls or other enclosures "intended to collapse under wind and water loads without causing collapse, displacement, or other structural damage to the elevated portion of the building or supporting foundation system." Safe design loading resistance is specified to be "not less than 10 and no more than 20 pounds per square foot" (Federal Emergency Management Agency, 1987).

Floodproofing For Utilities

Additional NFIP minimum criteria require that public utilities and facilities, including sewer, gas, electrical, and water systems, be located and constructed to minimize or eliminate flood damage. The NFIP performance standards for floodproofing structures have been incorporated (often with variations) into many local and state building codes and into the principal regional building codes.

Many technical reference documents have been prepared to assist builders and regulators in meeting performance standards for residential and nonresidential construction in flood hazard areas. Prominent examples of these reference documents include *Flood-Proofing Regulations* (Office of the Chief of Engineers, 1972), *Coastal Construction Manual* (Federal Emergency Management Agency, 1986), and the *Design Manual for Retrofitting Flood-Prone Residential Structures* (Federal Emergency Management Agency, 1986a). States have produced similar reference documents that provide guidance specific to local conditions and regulations/standards. These state-prepared documents are often based on the documents prepared by federal agencies.

SHORELINE SETBACK STANDARDS

NFIP criteria impose no minimum distances that structures must be set back from river channels, and no other national standards for stream setbacks exist. Some states and communities, however, have developed setback standards that may apply to designated streams, lakes and other water bodies.

Lincoln Township, Michigan, located on Lake Michigan, established setbacks of 110 feet from dune and bluff areas (Kusler, 1982).

The State of Wisconsin — through its shoreland management program — requires a minimum building setback of 75 feet from the ordinary high-water mark[6] (Wisconsin Department of Natural Resources, 1982).

In coastal areas, NFIP criteria require that all structures be "located landward of the reach of mean high tide." Several coastal states have established setback standards significantly more stringent than the NFIP requirements. Coastal setback standards are typically based on estimated erosion rates, or goals for the protection of sand dunes and other natural features.

North Carolina established setback requirements with four "tiers." First, no development may be permitted seaward of the vegetation line; second, from the vegetation line landward to a distance of 30 times the annual erosion rate (60-foot minimum), no permanent substantial structures are allowed; third, small structures (less than four units and/or less than 5,000 square feet of floor area) can be located between 30 times and 60 times the annual erosion rate landward of the vegetation; and fourth, larger structures must be set back at least 60 times the annual erosion rate behind the vegetation line (Owens, 1984).

Additional setback standards that apply within "zones of imminent collapse" were established as part of the NFIP in December 1987 with passage of Section 544 of the Housing and Community Development Act of 1987. This Act provides for insurance payments for shorefront structures (i.e., located on tidal, lacustrine or riverine shorelines) in imminent danger of collapse due to erosion. Insurance payments may be authorized to either relocate the structure or to reimburse the owner for the value of the structure and its demolition. Any reconstructed or relocated buildings must be set back from the shoreline. To be eligible for flood insurance, residential structures containing one to four dwelling units must be set back beyond the 30-year erosion line, and other structures must be set back beyond the 60-year erosion line.[7]

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6 This provision is part of shoreland zoning regulations that are required for all unincorporated areas of each county, but are optional for incorporated areas. The purpose is to protect the quality of the shore and is not directly related to reducing flood damages (Riebau, 1988).

7 These setback requirements were based on the North Carolina regulations described previously.

PROTECTION OF NATURAL RESOURCES

The only nationwide standard protecting floodplain natural resources and specifically relating to flood loss reduction has been established as a minimum requirement of the NFIP. This requirement prohibits "man-made alteration of sand dunes and mangrove stands within ... [V-zones] ... which would increase potential flood damage" (Federal Emergency Management Agency, 1987).

STANDARDS FOR FLOOD PROTECTION STRUCTURES

Important standards for flood protection structures address the design, construction and operation of dams, reservoirs and levees.

Dam and Reservoir Standards

There are no nationwide standards applicable to all dam and reservoir construction. Each federal agency with responsibilities for construction, maintenance, and inspection of dams has developed its own set of criteria, generally addressing both flood and earthquake design criteria. The Corps of Engineers, as part of its National Dam Inspection Program, developed classifications for size and hazard potential that could be applied to nonfederal dams, and also developed a set of "Recommended Guidelines for Safety Inspection of Dams." The Interagency Committee on Dam Safety (ICODS) has developed guidelines for dam safety that are being adopted by federal agencies responsible for dam safety. Additionally, these and other guidelines are used by many states to establish their own dam safety standards (National Research Council, 1985). Chapter 12 provides additional information about dam safety and the criteria for classifying dams and reservoirs.

Levee Standards

The three agencies that construct most federally funded levees are the Corps of Engineers, the Soil Conservation Service, and the Bureau of Reclamation (BOR). Each of these agencies have developed policies for levee construction and maintenance. Although these policies differ somewhat, they basically conform with standards adopted by the Corps, including the requirement that design height be equal to a specified design flood level with freeboard provided for additional safety. The required minimum freeboard is generally three feet, with added height required in areas of constricted flow and where structures are located near the levee. Emergency levees and many small agricultural levees intended to provide protection from an immediate flood or from smaller floods (e.g., five to 25-year flood frequencies) may be excepted from these design requirements.

For nonfederally funded levees, there is no direct federal control over construction and maintenance standards, and levees have been constructed to provide different levels of flood protection. As a result, some debate has occurred for several years among federal and state offices as to how these levees and the protection they provide should be treated for flood insurance purposes. In response, FEMA developed a temporary policy for mapping the areas behind levees. In accordance with this policy, areas behind levees were considered as protected from the one percent annual chance flood only if the levee could be certified as designed and constructed to the one percent annual chance flood level with a minimum of three feet of freeboard (Federal Insurance Administration, 1981). This temporary policy was subsequently modified and in 1986 new standards were promulgated as regulations. The regulations now provide for mapping areas behind levees as protected from the one percent annual chance flood only if the levee system provides protection from that flood, as determined through application of FEMA-established design criteria for freeboard, closures, embankment protection, embankment and foundation stability, settlement, and interior drainage.

The design criteria for freeboard apply to both riverine and coastal levees. Riverine levees must provide a minimum freeboard of three feet above the water surface level of the one percent annual chance flood. An additional one foot above the minimum is required within 100 feet of either side of structures located on the stream side of the levee or wherever the flow is constricted. An additional one-half foot above the minimum is also required at the upstream end of the levee, tapering to not less than the minimum freeboard at the downstream end. For coastal levees, the freeboard must be one foot above the height of the one percent annual chance wave or the maximum wave run-up (whichever is greater) associated with the "100-year" stillwater surge elevation at the site. An exception to this standard is allowed if the levee is designed by a federal agency with responsibility for levee design (Federal Emergency Management Agency, 1987).

These FEMA regulations provide significant incentive for states and communities to approve only those levees that meet established criteria.

NATURAL RESOURCES PROTECTION STANDARDS

Prescriptive standards and performance standards are applied to protect natural resources as well as to reduce flood losses. Few, if any, of the standards for natural resources protection are applied specifically to floodplains. Instead, they typically apply to the particular resource of concern, wherever that resource may be found — either in or out of a floodplain.

WATER QUALITY STANDARDS

The Clean Water Act, originally passed in 1972 (P.L. 92-500) and subsequently amended several times, required the U.S. Environmental Protection Agency (EPA) to establish several types of water quality criteria and to adopt, or delegate to qualifying states the authority to adopt, water quality standards to protect designated water uses. Water quality standards are applied to achieve the Act's interim goals of having all surface waters "fishable and swimmable wherever attainable."

The EPA publishes information on the impact of surface water pollutants on aquatic life and human health. The Agency is also developing criteria pertaining to sediment pollution. This scientific information is used by the EPA and the states in adopting water quality standards enforceable through National Pollution Discharge Elimination System (NPDES) permits. Best management practices (BMPs) have also been identified to limit the type and amount of pollutants generated from nonpoint sources.

The EPA has established standards for potable water and, more recently, has been responsible for establishing acceptable levels of toxic and hazardous substances in drinking water.

WETLAND CLASSIFICATION AND DELINEATION

As described in Chapter 2, several definitions of wetlands have been used by different federal agencies to meet their own program needs. In January 1989, the Corps of Engineers, the EPA, the U.S. Fish and Wildlife Service (FWS), and the SCS signed an interagency agreement to adopt a single consistent approach for determining wetland areas under the jurisdiction of federal programs (Cohen, 1989). Under this agreement, wetlands are determined to possess three essential characteristics: 1) hydrophytic vegetation; 2) hydric soils; and 3) wetland hydrology. A new manual entitled "Federal Manual for Identifying and Delineating Jurisdictional Wetlands" was developed and distributed during the Spring of 1989 for use by field personnel in delineating wetlands according to the newly adopted approach. The manual describes technical criteria for each of the characteristics that must be present for an area to be considered a wetland under federal jurisdiction. (Federal Interagency Committee for Wetland Delineation, 1989).

As part of the National Wetlands Inventory, the FWS has categorized wetlands and deepwater habitats according to five ecological systems: marine, riverine, lacustrine, estuarine and palustrine (see Chapter 2). This standard categorization makes it possible to delineate the different classes of wetlands using aerial photography, supplemented by field checks, throughout the Nation.

Many states have their own procedures for identifying and delineating wetlands, usually based on state legislation. Typically, state procedures rely on a combination of vegetation and soil characteristics to identify wetlands, but procedures using only soils criteria (Connecticut) and only vegetation (New York) are also in use.

HABITAT EVALUATION METHODS

Several types of habitat evaluation procedures are in use but no single procedure has achieved the status of a national standard. Four procedures used at the national level are those developed by the Corps of Engineers, the FWS, the Federal Highway Administration (FHWA), and the EPA.

Wetland Evaluation Technique

The Corps and the FHWA have combined efforts to produce the Wetland Evaluation Technique (WET) that is now being used by the Corps, the FHWA, and the EPA to rapidly assess the functional values of wetlands. The WET is a tool for conducting an initial, rapid assessment of wetland functions and values. Considered a "broad brush" approach, it is normally used to assess existing conditions and is designed for use in the 48 contiguous states (it is not for use in Hawaii, Alaska or the territories). The WET assesses 11 wetland functions and values in terms of social significance, effectiveness and opportunity, and assesses the suitability of wetland habitat for species and species groups.

The Corps of Engineers became involved in the development of methodologies for wetland evaluation in the 1970s in response to its regulatory authority under Section 404 of the Clean Water Act. Wetland functions and values were first addressed in Corps permit regulations in 1973. Development of a wetlands evaluation manual was initiated in 1976 and the manual was published in 1979. Entitled *Wetland Values: Concepts and Methods for Wetlands Evaluation* and developed by the U.S. Army Engineer Institute for Water Resources, the manual contained a nonmonetary evaluation method (in part because the Corps' regulatory program did not require economic valuation of wetlands), and expressed wetland value in terms of relative efficiency in the performance of recognized functional characteristics (Reppert, 1981).

Following development of this methodology, the Corps of Engineers continued to research wetland evaluation techniques. Forty techniques published prior to 1981 were reviewed and no single technique was found to provide an adequate framework for developing a method responsive to the Corps' needs. The Corps also surveyed 37 district offices to determine assessment techniques in use and found that these different Corps districts did not use formal wetland assessment methods but relied primarily on professional judgment.

The Corps concluded that although no single assessment procedure afforded the capability for accurately quantifying all wetland functions, a procedure developed for the FHWA provided an excellent framework for assessment. As a result, the FHWA technique (also known as the Adamus method and entitled "Method for Wetland Functional Assessment, Volume II") was tentatively adopted by the Corps as the basis for a wetland functions and values assessment procedure (Clairain, 1985).

A revised methodology — the Wetland Evaluation Technique — was jointly released by the Corps and the FHWA in 1987. The WET methodology involved several changes from the previous FHWA version and included development of a computer program for data analysis on microcomputers. The WET methodology was released as an operational draft, and further modification is expected (Adamus, 1987).

Several states have developed their own wetland evaluation procedures.

Wetland Evaluation Technique for Bottomland Hardwood Functions

In 1987, the EPA released a technique "intended for use in identifying the level of functioning of a specific bottomland hardwood (BLH) tract, in comparison to the entire set of all BLH tracts ..." The procedure, referred to as WET-BLH, is a streamlined version of the WET methodology adapted specifically for the bottomland hardwood region of the southeastern United States (Adamus, 1987).

Habitat Evaluation Procedures

In 1980, the Fish and Wildlife Service developed a methodology for quantitative evaluation of the suitability of wetlands and other habitat types for fish and wildlife species. This method, called the Habitat Evaluation Procedures (HEP), combines habitat "... quality and quantity in a single index value that can be used to rank present wetland values and compare baseline conditions with land use changes for selected target years" (Schamberger, 1979).

An earlier version of the system was published as the "Ecological Planning and Evaluation Procedures" in 1974. The current HEP can be used to inventory baseline wetland conditions, formulate alternative land-use plans, evaluate alternate sites, and determine compensation requirements.

ACCEPTABLE RATES OF SOIL EROSION

The Soil Conservation Service has developed criteria to determine "acceptable" or "tolerable" levels of annual soil erosion for each soil type found throughout the country. These levels of erosion are measured in terms of tons of soil lost per acre. The acceptable level of erosion is based on the concept of maintaining long-term productivity of the soil for agricultural purposes, and takes into account the estimated rate at which new soil is created. The tolerable rate of erosion is commonly referred to as a "T" value, and soil erosion from a particular field at a rate twice the tolerable level is referred to as a "2T" (Schertz, 1983; Johnson, 1987).

The concept of tolerable soil loss erosion is used by the SCS and local conservation districts in developing management plans for agricultural practices. Under provisions of the Food Security Act of 1985 (P.L. 99-198), farming operations receiving commodity assistance payments from the Department of Agriculture must reduce erosion to specified "T" levels by the early 1990s.

SUMMARY AND CONCLUSIONS

Floodplain regulatory and design standards — including prescriptive and performance standards — provide a means for uniform application of floodplain management practices, and for the review and evaluation of flood loss reduction and natural resources protection projects. Nationwide standards are typically established by federal agencies as part of program regulations or sometimes directly by Congress. States and communities frequently adopt more stringent standards than apply nationally.

Many of the nationwide standards for flood loss reduction now in use are directly derived from the minimum floodplain management requirements of the National Flood Insurance Program. Important nationwide standards have been established with respect to: the one percent annual chance flood and floodplain; the regulatory floodway; coastal flood elevations; and elevation of structures above the one percent annual chance flood level.

Several states have established requirements for development to be set back a specified distance from the shoreline, particularly in coastal areas. These shoreline setback standards are generally based on estimated erosion rates or the need to protect natural features.

Few, if any, of the standards for natural resources protection have been developed specifically for floodplain application. Instead, these standards typically apply to a particular resource to be protected whether the resource is found in the floodplain or not. In addition to shoreline setbacks to protect natural features, several national standards have been established to protect natural resources. These include water quality standards (both instream standards and discharge standards) and wetland classification and delineation standards. In addition, standardized techniques for wetland and habitat assessment have been developed, and "tolerable" rates of soil erosion from agricultural land have been established.

CHAPTER 9:

PERCEPTION, AWARENESS AND RESPONSE

> ... *[W]hile flooding is a serious national problem, it is not perceived as a very important concern in most communities in the United States.*
>
> *Flood Plain Land Use Management*, Burby and French, 1985

Both individual and institutional perception and awareness of flood risk and vulnerability are major factors affecting response to flood hazards. While substantial progress has been made in increasing institutional awareness and response, individual perception and awareness generally falls far short of the level that many professionals and public officials feel is needed. One result of inadequate awareness of flood risk and vulnerability is the inappropriate development of floodprone areas. In addition, only a portion of the affected public usually responds appropriately to flood warnings, and this lack of response sometimes has grave results.

There will always remain a segment of the population that will not take preventative actions in response to flood risk information. Some people will not understand or accept information on flood risk provided to them, particularly if they have not personally experienced serious flooding. Others understand the risk but are willing to take that risk and feel they have the right to do so. Often their strong desire to live near a river or on the coast overrides concerns for personal safety or damage to property. And then there are those who feel that if a problem does exist, it should be "fixed" by the government.

Both the "public good" and "individual rights" can be affected by perception and awareness of hazards and response to hazard-related information. When the public good conflicts with individual rights, some balance must usually be achieved. Some individuals seem not to realize that by choosing to live in a hazardous location they are imposing costs on others through expenses for infrastructure, emergency services, disaster relief, flood insurance, and other governmental activities.

While far from universal, individual awareness of the natural resources associated with floodplains is now far more widespread than it was 15 or 20 years ago. The importance of preserving wetlands, protecting endangered species, and maintaining water quality is widely recognized. Yet this awareness does not necessarily translate into actions that will preserve or restore these floodplain resources, particularly if the actions would affect an individual's own property. Any restriction of individual property rights to protect natural resources may be strongly resisted, or the natural resource loss may be viewed as inconsequential because of the small area affected.

RECOGNITION OF FLOOD RISK AND RESPONSE TO FLOOD WARNINGS

The extent to which flood risk is recognized and flood warnings are heeded is largely dependent on public perception and awareness. Government agencies can help to increase awareness in various ways — through information and education programs, for example, as well as regulatory measures. In some instances, floodplain management terminology is an obstacle to risk perception.

PERCEPTION OF FLOOD HAZARD

Local perception of flood hazard by both governments and floodplain residents may be related to several key factors, among which are previous experience with flooding, the extent of development in the floodplain, and the existence of structural flood control measures. The response of a community or an individual to the perceived risk may depend on these factors as well as the seriousness of the flood problem in relation to other community problems. Prevailing attitudes about land use and related water resources management measures may also affect response.

In their 1985 assessment of floodplain land-use management, Burby and French (1985) included an examination of local perception of the flood problem. Many of their findings were consistent with other studies of the perception of flood risk and are summarized in this section of the *Assessment Report.* Burby and French concluded that:

> *. . . while flooding is a serious national problem, it is not perceived as a very important concern in most communities in the United States. Potential property losses from floods are the most widely recognized problem of flood-hazard areas. In addition, a number of communities are also aware of environmental problems within the bounds of their flood plains. In general, communities do not attach very high priority to solving flood plain problems. Where problems are most serious, however, communities do seem to be concerned and are placing a high priority on governmental action to resolve them.*

Most people discount the probability of loss from infrequently occurring events, such as major floods. In keeping with the results of several other studies,[1] Burby and French found that in the communities they surveyed, although local officials recognized that property loss from flooding was a problem, "flooding was not viewed as a critical or even a serious issue." While property loss from flooding, erosion and sedimentation were recognized as problems by a majority of the communities surveyed, other related issues (e.g., damage to public facilities, encroachment on natural areas, concentration of poor housing in flood hazard areas) were cited much less frequently.

Solution of floodplain problems is generally not given high priority, except where communities have experienced severe or frequent floods. Because flooding is not perceived as a serious problem, finding solutions to flood-related problems is often given a low priority relative to other community concerns. However, individual and community experience with flooding has been shown to result in both

1 Studies cited by Burby and French included: Burton (1972); Rossi, Wright and Weber-Burden (1982); Mileti, Drabeck and Haas (1975); and Kunreuther, et. al. (1978).

heightened perception of risk and increased attention to solving flood problems. Previous experience with flooding has been related to individual perception of flood hazard, belief in hazard warnings, and adoption of hazard mitigation measures.[2] A study conducted by the University of Massachusetts (Rossi, 1982) related the perception of community leaders regarding the seriousness of flood problems to the community's experience with flooding. Burby and French found that fewer than 10% of the communities they surveyed assigned highest priority to floodplain problems, but "the proportion of communities that gave high priority to solving flood plain problems was much larger than average among jurisdictions with severe flood plain problems."

Local perception of the flood risk was an important contributor to the scope and focus of a community's floodplain management program — more so than actual floodplain characteristics and flood problems. "In addition, ... the more concerned communities are with their flood plain problems ... the more likely they are to have adopted broader and more direct management measures."

Perception of flood risk may also be related to the extent and nature of floodplain development. For example, in communities with intensively developed flood hazard areas (and limited sites outside the hazard area), "The perceived seriousness of the flood problem is directly associated with the extent of flood plain development and the existence of intensive land uses (apartments, commercial, and industrial uses) in the hazard area. Those are also the communities, however, in which a higher proportion of new construction is occurring in flood zones." Increasing development may also result in greater awareness of flood problems. "As urbanization increases, more individuals and groups in a community are likely to become concerned with particular problems and to have the expertise to stimulate community action to resolve them ... Communities with larger populations, those growing at a faster rate, and those located in metropolitan areas are more likely than others to have adopted broader and more direct flood plain land use management programs."

The presence of structural flood control measures may have varying effects on perception of flood risk and on subsequent responses to flood problems. Some studies have shown that adoption of structural control measures results in a sense of complacency about the community flood problem or discourages adoption of alternative nonstructural measures to reduce losses. On the other hand, Burby and French found that "communities are more (rather than less) likely to believe they have a flood problem when they have some form of structural protection in place ...," and "that they are more (rather than less) likely to have adopted a broad-gauged flood plain land use management program." However, they also noted that "... while local governments continue to be aware of the flood problem, citizens within these communities may believe that the structural measures solved the flood threat and, as a result, may continue to expose themselves to flooding."

The degree of risk perception and the type of management measures adopted to respond to the flood problem may also be affected by the type of flood hazard present. "The threat of damage from coastal flooding seems to be taken more seriously by communities than damage from riverine flooding. As a result, coastal areas are more likely to use more direct hazard management measures than riverine communities ... In general, riverine communities are most interested in land use management

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[2] See Roder (1961); Kates (1971); Mileti, Drabeck and Hass (1975); Kunreuther, et. al. (1978); and Miler (1977).

when they are experiencing an intermediate level of risk ... Apparently, communities with less intensive flood plain development do not view the flood problem as serious enough to warrant a major management effort, whereas those with more heavily developed flood plains look to other solutions for their problems, such as flood control structures."

Individual perception of risk by floodplain residents may be quite different than the perception of local officials. Individuals in a community may consider themselves protected from flood damages by structural measures, while the local government remains concerned about potential flood losses. Studies of the relocation of floodplain occupants have provided information on risk perception. Even if the flood risk is known, the advantages of a floodplain location may outweigh the disadvantages. Homeowners may also be more concerned with the effect of floodplain regulations on resale property values than with potential flood damages.

Both individual and community perception of risk may be tempered by other community values. For example, "... individual and community resistance to [floodplain land use management] programs is often based on apprehension about the 'secondary' effects of land use management. Adverse economic effects that are often attributed to flood plain land use management include reduction in property values, reduction in community economic growth and development, reduction in the tax base, and increased construction costs. Adverse social effects can include increased community conflict over regulation and inequitable costs to low- and moderate-income households" (Burby, 1985).

GOVERNMENT ROLES FOR INCREASING AWARENESS

Following a review of research and experiences regarding public awareness and government programs for increasing awareness of natural hazards (including hazards other than floods), Davenport and Waterstone (1979) suggested appropriate roles for each level of government. These suggested roles for increasing awareness continue to merit testing and adjustment and are as follows:

1) FEDERAL GOVERNMENT: Federal agencies and federally supported research would provide:

- general information on each hazard;
- federal legislation and policy support for awareness and other hazard mitigation efforts;
- technical assistance (delineation and mapping of hazard zones, advice on building standards, floodproofing, etc.);
- basic preparedness advice;
- encouragement of long-term planning with aim to lessening future losses;
- support for good research regarding human attitudes and response to various natural hazards so as to increase efficiency of future awareness programs; and
- survey damages after a disaster for use in refining future preparedness efforts.

2) STATE GOVERNMENT: State governments would provide:

- planning and development of basic materials keyed to a specific state which can then be localized;
- a good pass-through for federal funds designated for awareness/disaster mitigation programs;
- aid in identifying risks;

- aid in identifying sources of funding and technical assistance, whether state or federal level sources; and
- providing support and perhaps funding for hazard awareness programs through state legislation and igniting interest on the local level for such programs.

3) LOCAL GOVERNMENT: Local officials and leaders were identified as having ultimate responsibility for increasing awareness and preparedness. Appropriate actions for local governments include:

- finding and using as a rallying point a community leader with good standing, credibility, and interest in the natural hazard problem;
- monitoring and updating descriptions of local conditions (road, building construction, population influx) which would impact public preparedness measures;
- encouraging participation in awareness programs by local businesses, industry, civic clubs, etc.; and
- localizing federal and state hazard awareness materials to fit a specific area or, if possible, developing their own where needed.

INCREASED AWARENESS THROUGH INFORMATION AND EDUCATION

The distribution of information and education on natural hazards typically proceeds from higher governmental levels of organization to lower levels. Much of the information relating to flood loss reduction and natural resources management has indeed been distributed from the federal government to state government to local government and finally to individuals. But this sequential pattern does not always apply. For example, much of the information and education about flood hazards has been distributed by federal agencies directly to both state and local governments and even to individual citizens. Likewise, state governments often attempt to educate and inform individual citizens as well as local government officials.

Information and education may also proceed from lower to higher levels, as state or local governments share their experiences with higher levels of authority. Frequently, new techniques and programs are initially developed at the local or state level, and are later incorporated into state or federal efforts, thereby achieving more widespread application.

Informing and educating the public about flood risk and appropriate responses and about the importance of preserving and restoring floodplain natural resources is an ongoing effort. Much research has been directed toward identifying the most effective means of providing information on flood risk and stimulating people to take action, and professionals in the fields of flood loss reduction and natural resources management continue to search for new and more effective means of informing and educating the public. Studies have shown that people receive their information in different ways and attach different levels of reliability to different sources. In general, these studies have shown that a variety of means must be used to distribute the message, and the message must be repeated frequently. Typical means of providing information include distribution of pamphlets and other publications, use of radio, television and newspapers, placement of warning signs, and many other more imaginative methods. Chapters 11, 13 and 14 of the *Assessment Report* describe many of these methods and include examples of their use.

FORCED AWARENESS THROUGH REGULATORY MEASURES

Unfortunately, even the best attempts to make individuals and communities aware of flood risks often fail to achieve the desired response. As a result, regulatory actions are often required. Chapter 11 provides a detailed description of many of the regulatory measures that have been instituted by all levels of government in an effort to force appropriate action to reduce flood losses. The widespread impact of the National Flood Insurance Program (NFIP) illustrates the effectiveness of (and need for) forced awareness through regulatory measures.

The NFIP is a voluntary program, but its voluntary nature has been modified since initial passage of the National Flood Insurance Act (NFIA) in 1968. Originally the program made insurance available to community residents if the community joined the NFIP and established minimum floodplain regulations. Few communities initially joined the program, and following the devastating flooding from Hurricane Agnes in 1972, Congress made several changes to encourage greater community participation in the program. Foremost among these Congressional initiatives was passage of the Flood Disaster Protection Act of 1973 which prohibits disaster assistance to communities identified as having floodprone areas but which have not joined the NFIP. A "first bite" approach is allowed, however, by which the community is permitted to join the NFIP, and the community and residents can then receive disaster assistance, even after a disaster has occurred.

Another NFIP mechanism intended to force flood hazard awareness on individuals is the requirement that federally insured banks and other financial institutions require purchasers of homes and other structures in the floodplain to obtain flood insurance. The financial institutions, however, are not subject to any regulatory penalty if they do not comply with this requirement.

During the first 15 years of the NFIP, communities often challenged the program and resisted adopting the required minimum regulations as a condition of flood insurance availability. For many communities, participation in the NFIP was their first experience with a land-use regulatory program. Now, after several generations of elected officials and senior civil servants have experienced the NFIP regulations, the prevailing attitude has shifted to one of figuring out ways to live with the program. Community experience in the courts, media coverage of flood disasters, and liability concerns have all contributed to a gradually increased awareness. As a result, the NFIP regulations have become institutionalized, and participation in the program is now generally accepted as a community responsibility.

A few jurisdictions require realtors to make flood and other hazard information available to prospective home buyers.

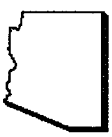
The City of Stamford, Connecticut requires developers of most projects within the one percent annual chance floodplain to prepare and file with the City an emergency preparedness plan. The City also requires that a notice be placed on local land records noting that the property is located within a flood prone area (Emerson, 1988).

TERMINOLOGY AS AN OBSTACLE TO RISK PERCEPTION

Some of the terminology associated with floodplain management almost certainly contributes to problems of inadequate awareness, perception and response. Several examples of commonly used but often misunderstood terminology follow.

"100-Year Flood"

Probably the most misunderstood floodplain management term is the "100-year flood." While this term is generally understood within the professional floodplain management community, the general public almost universally does not properly understand the meaning of the term. As described in Chapter 8, the "100-year" flood is simply another term to refer to the one percent annual chance flood — the flood that has a one percent chance of being equalled or exceeded each year. A flood of that magnitude will occur on average once each 100 years, hence use of the term "100-year flood." Unfortunately, the term is often taken literally, with individuals believing that if they have experienced a "100-year" flood, another flood of that magnitude will not occur for another 100 years. The term can be especially confusing when a series of flood events changes the current estimate of the "100-year" flood. Such changes are common as a result of both short-term gage records and increased runoff due to urbanization.



After major flood events in 1978 and 1980, the estimated magnitude of the "100-year" flood on the Salt River in Phoenix was reduced to approximately that of a "50-year" flood (Bond, 1988).

In an attempt to reduce confusion, some practitioners prefer to use the term "one percent annual chance flood,"[3] noting that in any given year there is a one percent chance that a flood of that magnitude could be equalled or exceeded. In practice, the term is often shortened to the "one percent flood" which may not convey the meaning as accurately. Other terms may be used to represent the one percent annual chance flood. For example, FIA regulations use the term "Base Flood" for the one percent annual chance flood. In conversation and in written documents, the terms "100-year flood," "base flood," and "one percent flood" may be used interchangeably, thereby confusing those who are unfamiliar with the terms and quite possibly misleading some individuals regarding the severity of the flood.

Still further confusion can result because the "100-year" flood is usually the only type of flood event referred to, even though larger and smaller floods will certainly occur. Many individuals tend to think of flooding only in relation to a flood of a "100-year" magnitude. Often overlooked is the fact that the "100-year" flood has been selected as a reasonable regulatory standard, and is not intended to describe the only magnitude of flood that will occur.

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[3] The term "one percent annual chance flood" is used throughout the *Assessment Report* except when use of the term would be confusing in association with quotes or other references.

As commonly applied, the concept of a "100-year" flood and floodplain — no matter what terminology is applied — can be very misleading. Technically, only the outer edge of the "100-year" floodplain has a risk of only one percent. Moving toward the stream, ocean or other water feature, or toward lower elevations, the risk rises. Yet the entire area between the water body and outer edge of the "100-year" floodplain typically is thought of as subject to the same risk. Flood Insurance Rate Maps (FIRMs) delineate areas of higher risk within the "100-year" floodplain.

"Floodproofing"[4]

The term "floodproofing" has often been cited as creating a false sense of security regarding the potential for flood damage. The techniques involved in "floodproofing" a structure do not make it completely safe from flooding. The term "flood resistent construction" has been suggested as an alternative. More recently, the terms "retro-floodproofing" and "retrofitting" have been used to apply to floodproofing of existing structures (Federal Insurance Administration, 1986).

The term floodproofing can be especially confusing or misleading if no distinction is made between "wet" floodproofing, which refers to use of construction techniques and materials that can withstand the effects of floodwater with little or no damage, and "dry" floodproofing, which refers to construction techniques designed to keep floodwater out of a structure.

As described in different contexts, floodproofing may or may not include the elevation of a structure above flood levels. NFIP regulations specifically distinguish between elevation of a structure and floodproofing of a structure. The Corps of Engineers, however, describes elevation as a type of floodproofing in several publications.

"Nonstructural Measures"

When the term "nonstructural measures" is used with regard to reducing flood losses, it may not always be clear what measures are being included or excluded by the term. The term was originally devised to distinguish techniques that modify susceptibility to flooding (such as regulation, floodplain acquisition and floodproofing techniques) from the more traditional methods (such as dams, levees and channels) used to control flooding. The distinction between structural and nonstructural measures, however, is not always clear.

For example, beach nourishment — the artificial replenishment of beach sand — is considered a structural measure by some and a nonstructural measure by others. Also, use of a small berm or dike to protect a single structure from flooding may be considered either a structural or nonstructural technique. Similarly, many "nonstructural" measures such as elevation or floodproofing clearly involve some alteration of a "structure." In addition, the lack of clarity associated with the terms "structural" and "nonstructural" detracts from the objective of utilizing the best mix of loss reduction measures for any given floodplain.

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4 See Chapter 11 for a more detailed description of floodproofing.

"Risk" and "Vulnerability"

Although these two terms have different technical meanings, they are often incorrectly used interchangeably. Risk is the relationship between the consequences resulting from an adverse event and its probability of occurrence. Vulnerability is the characterization of the nature and extent of damage that may occur during flooding. For example, the floodplain on both sides of a river may be subject to essentially the same risk of flooding. If the floodplain on one side has been developed with homes while the other has not been developed, only the developed floodplain would be considered vulnerable to damage from flooding.

"Mitigation"

"Mitigation" has become a popular term in recent years, but it has no consistent definition among users. The term is somewhat of a "catch-all" for any activity related to flood loss reduction, although individual users typically tend to exclude certain types of activities from the term. Some may exclude emergency preparedness from mitigation, others may exclude flood response activities, and still others may exclude short- or long-term recovery activities.

The Federal Emergency Management Agency (FEMA) has defined mitigation as follows:

> *Mitigation is any action taken to eliminate permanently or reduce the long-term risk to human life and property from natural and technological hazards*. (Federal Emergency Management Agency, 1987).

"Tidal Wave"

The term "tidal wave" is still mistakenly used by many to refer to "tsunamis" which are more properly described as seismic sea waves.[5] These waves have no relationship to tides. Nor are they related to storm surge and related large waves that may be caused by hurricanes or other major coastal storm's (Forrester, 1987).

AWARENESS OF FLOODPLAIN NATURAL RESOURCES

As noted in Chapter 2, much attention has historically been focused on the hazards associated with flooding and floodplains, and less attention has been directed toward floodplain natural and cultural resources. In recent years, however, the natural resources associated with floodplains — particularly wetland resources — have been the subject of increased scientific study and management. While the protection of floodplain natural resources has not emerged as a popularly expressed environmental objective, such an objective is encompassed in the broader environmental goals (particularly for the protection of wetlands and water resources) embraced throughout the Nation. The general public

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5 See Chapter 1 for a more detailed description of tsunamis.

level of environmental awareness and support for environmental protection programs has increased dramatically in the past quarter-century. This awareness is seen to represent a potentially broad base of public support for programs aimed at the protection or restoration of floodplain natural resources.

In general, the development of environmental programs from the 1970s and the experience of these programs have provided a basis for understanding newly identified environmental challenges. Furthermore, recent opinion surveys show that a majority of Americans believe that poor environmental quality is one of the most serious National problems (Gilbert, 1990), and that most are willing to pay for necessary actions to improve the quality of the environment. Pollster Louis Harris testified before a Senate subcommittee that public support for environmental improvements was higher than for any other national objective he had ever surveyed (Grove, 1990).

In the 1960s and 1970s, those concerned with protection of the natural environment were often perceived as more concerned with wildlife (protecting whales, whooping cranes and wilderness areas, for example) than with human life. As a result of this image, many Americans did not take environmentalists seriously and viewed them as threats, particularly to economic growth (Gallop, 1984).

In the 1980s, however, the environmental movement developed much broader public support. A national poll conducted in 1981 indicated that 45% of the population felt that "protecting the environment is so important that requirements and standards can not be too high and continued environmental improvements must be made regardless of cost." Fifty-eight percent agreed with this same statement in 1983, and a 1986 New York Times/CBS poll found the percentage of the population in agreement had increased to 66%.

Because the natural and beneficial resources of wetlands, once poorly understood, have been the subject of much attention and study in recent years, public awareness and understanding of the importance of wetlands in the natural environment is generally high. Concern over wetland losses and support for wetland protection appears to be increasing. A 1982 Harris Poll found that 83% of those responding felt that it is "very important" to preserve the remaining wetlands. A 1985 Harris Poll reaffirmed broad support for continued wetlands protection as 85% of those polled favored strict enforcement of the Clean Water Act and its wetland protection requirements (President's Commission, 1987).

The National Wildlife Federation (NWF), first included an Environmental Quality (EQ) Index in *National Wildlife* in 1969. The EQ Index monitors and reports the state of the environment and gauges public awareness concerning the environment. In the 1960s, this awareness moved from indifference to a demand for action. As a result, during the 1970s much federal legislation was enacted to direct the cleanup of the Nation's natural resources.

According to the NWF, the 1980s have seen public interest in the environment lag somewhat, but a simultaneous development of environmental professionals has occurred over the last decade. The EQ Index documents "the steadily growing, increasingly steadfast acceptance by the American people of the necessity of the fight" for a cleaner environment. The president of the NWF, stated "the greatest accomplishment of the environmental movement since Earth Day [in 1970] has been putting our strong desire for environmental protection at the heart of the quality of life in our society."

Earth Day 1990 (April 22) celebrated the 20th anniversary of the first Earth Day that many point to as launching the modern environmental movement. The celebration demonstrated the existence of what can be described as the Nation's growing environmental populism and focused attention on many of the environmental problems that are more pressing today than they were 20 years ago.

Gaylord Nelson, the former U.S. Senator from Wisconsin, has noted that "... Earth Day, as was intended, demonstrated to the Washington establishment and the public that there was an environmental movement. The principle and lasting effect was to make environmental concerns a permanent part of the political dialogue in this country. Obviously, not all members of Congress are now what I would call environmentalists, but almost without exception they are sensitive to environmental issues ..." (Gilbert, 1990).

SUMMARY AND CONCLUSIONS

Clearly, the public perception, awareness and response to both flood hazards and the natural resources of floodplains is now much greater than it was in the mid-1960s. There also is greater recognition that natural environmental values and flood risk are closely related.

The effects of information and education combined with the application of regulatory measures and other floodplain management tools have significantly increased public perception, awareness and response. Nevertheless, there is much room for additional improvement. Floodplain managers must seek new and improved methods, as well as greater implementation of existing methods, to reach those who have not yet acquired a sufficient level of awareness or the motivation to act at appropriate times and in appropriate ways. In doing so, floodplain managers should target government officials, floodplain occupants, and the general public. Methods appropriate for increasing the perception, awareness, and response of each group are necessary.

CHAPTER 10:

LEGAL INTERPRETATIONS BY THE COURTS

No higher duty can devolve upon the city authorities than that of protecting the property, health, and lives of the people; this is their permanent duty — a duty which cannot be evaded, nor can their right to do so be lost by neglect or bartered away.

City of Welch v. Mitchell, 121 S.E. 165 (1924)
(The first case involving floodplain regulations)

In the last several decades, government floodplain management measures have often been legally challenged by individuals who oppose the measures or claim that the measures have increased flood damages (U.S. Water Resources Council, 1971, 1972; Kusler, 1982). While only a few law suits opposing floodplain regulations have succeeded, many successful suits have been brought against government actions that have increased rather than decreased flood or erosion losses.

Litigation has been of two types: 1) "constitutional" challenges to floodplain regulations and other loss reduction measures such as multi-objective resource management regulations (e.g., wetland regulations); and 2) "liability" suits based primarily upon common law theories and initiated by those suffering losses as a result of government interference with drainage or flood flows or incorrectly designed, maintained, or administered flood loss reduction measures (dikes, levees, warning systems, etc.) (Annots., 1948, 1949, 1958, 1964, 1975). A successful constitutional challenge may prevent the implementation of a floodplain regulation. In contrast, a successful liability suit will not necessarily prevent implementation of a measure but will require government payment for flood damages.

In recent years, the constitutionality of floodplain management measures and the threat of successful claims for damages have been of increased concern to floodplain managers. The concern is due to a small number of lower court decisions challenging the constitutionality of land-use regulations, and three 1987 United States Supreme Court decisions that did not invalidate floodplain regulations but were widely represented to have done so. The concern is also due to the many court decisions that have held units of government liable for actions that increased flood or drainage damages.

This chapter examines the constitutional challenges and liability suits pertaining to floodplain management as well as the actions that governments are taking to reduce potential legal problems. The focus of the chapter is on floodplain management measures specifically designed to achieve broader multi-objective goals such as wetland protection, waterfront renewal, and water quality protection. Many of the legal issues associated with these broader measures, however, are also associated with the more specific measures (Kusler, 1980, 1982). The broader measures, along with flood loss reduction measures, have been supported by the courts.

Included in this chapter is an overview of the court decisions that have addressed public flood loss reduction measures in the last two decades. Major legal issues and trends throughout the United States are emphasized rather than the law in a particular jurisdiction. The emphasis is on those cases decided in the last eight years because these cases reflect recent legal thinking and because the information presented in the chapter is intended to update rather than replace the legal discussions found in Volumes 1, 2 and 3 of *Regulation of Flood Hazard Areas to Reduce Flood Losses* (U.S. Water Resources Council, 1971, 1972; Kusler, 1982).

TRENDS OVER THE LAST TWO DECADES

The types of lawsuits and the specific issues litigated have changed over the last twenty years. These changes have reflected the predominant floodplain management technique or techniques in use at the time, the general status of constitutional and tort (liability) law, and unresolved legal issues concerning loss reduction techniques.

PRIOR TO 1968

During the early years of floodplain management, the principal floodplain management techniques were flood control techniques and, not surprisingly, most lawsuits concerned flood control or drainage measures (Annots., 1948, 1949, 1958, 1964). A wide range of factually specific and statutorily specific issues were litigated (U.S. Water Resources Council, 1971). Suits included both constitutional challenges to flood control measures and claims for damages. Some of the issues addressed included the adequacy of the power of various units of government to undertake flood control, government liability for failure to operate and design adequate flood control works, and the sufficiency of eminent domain awards. Overall, government flood control efforts were widely upheld in the courts although governments were held liable for damages resulting from blockage of flows and/or inadequate operation or maintenance of channels, dams, dikes or levees.

Floodplain regulations were challenged in only a small number of suits, reflecting the small number of communities with adopted regulations (U.S. Water Resources Council, 1971). Most of the suits challenged the overall constitutionality of these regulations by examining the adequacy of: 1) statutes to authorize such regulations; 2) regulatory objectives; 3) the reasonableness of regulations in meeting specific goals; and 4) whether floodplain regulations were a "taking" of private property. Overall, regulations were sustained in the period prior to 1968 although several courts invalidated highly restrictive regulations as "takings" of private property.[1*]

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* Citations to court decisions are listed at the end of the chapter.

1968-1978

In the period 1968 to 1978, the number of successful lawsuits against governments for flood damages increased dramatically due to expanded concepts of liability and a reduction in government defenses against lawsuits (described later on) (Kusler, 1982).

During this decade, landowners challenged regulations on constitutional grounds in a relatively large number of suits, reflecting the huge increase in the number of states and communities with regulations. The nature of these suits shifted from broad-scale constitutional attacks to very specific challenges concerning the reasonableness of particular floodplain management measures such as floodproofing requirements and prohibition of residences in a floodway.

1978-1988

In this decade, courts continued to hold governments liable in an increasing number of contexts for actions that increased flood damages. The number of constitutional challenges to regulations, however, was much smaller due to the widespread legal support for regulations established in the previous twenty years. Cases addressed relatively technical issues such as the validity of nonconforming use provisions and setbacks. In 1987, however, the U.S. Supreme Court issued three controversial land-use decisions (see below) that have created a great deal of public confusion concerning the constitutionality of hazard regulations.

CONSTITUTIONAL CHALLENGES

Constitutional challenges to floodplain management measures can be described in the context of the three recent and controversial Supreme Court decisions, and in the broader context of the various types of challenges that have been brought against regulations and other flood loss reduction measures. It is also important to note some of the important types of floodplain management measures that the courts have sustained over the past 20 years.

THE THREE U.S. SUPREME COURT DECISIONS AND THEIR IMPACT ON FLOODPLAIN MANAGEMENT

In the summer of 1987, the U.S. Supreme Court issued three land use-related decisions that were widely (and inaccurately) reported in the press and which have been the subject of a great deal of discussion. Two of these decisions concerned hazard-related regulations.

While the decisions are of primary interest from a constitutional perspective, they also affect government liability. Prior to these decisions, government units adopting flood loss reduction measures were, in most jurisdictions, liable in damages only for increasing flood losses, not for tightly regulating floodplain development. A government unit only needed to modify the regulation if a court held that the regulation was a taking of private property without payment of just compensation. As a result of the Supreme Court's 1987 decisions, a government unit might now be liable for damages caused by overly restrictive regulations.

The three decisions are not easy to reconcile or interpret. They involve highly technical issues of law and are, to some extent, contradictory. In fact, they appear to raise more questions than they answer.

In the first of the decisions, *Keystone Bituminous Coal Association v. DeBenedictis*,[2] the U.S. Supreme Court upheld a 1966 Pennsylvania statute that prohibited the mining of coal where removal of coal would cause the subsidence of residences, public buildings, or cemeteries. Several coal companies had challenged the law as a taking of property because it effectively prevented the removal of 27 million tons of coal and because the companies had acquired rights to subside the land from some of the landowners.

In this case, the Court, citing 70 years of precedents, held that there was no "taking" because the regulations were adopted to serve valid health, safety and welfare goals, and because, overall, coal companies had not shown that the regulations denied them economic use of their land.

This decision, if read by itself, would suggest that the Court was willing to give even more support to health and safety-related regulations than previously. It is the only one of the three decisions that focuses on the validity of safety-related regulations.

Three months after the Keystone decision, the U.S. Supreme Court issued a second decision concerning the validity of hazard-related regulations. In this decision — *First Evangelical Lutheran Church v. County of Los Angeles*[3] — the Court held that <u>if</u> a temporary building moratoria adopted by Los Angeles County after a severe flood was a taking of private property, temporary damages should be awarded to the landowners (First Evangelical Lutheran Church) who had been prevented from rebuilding in a high risk flood area. While the *Keystone* decision had gone almost unnoticed by the press, this decision became front page news across the Nation.

Unfortunately, the *First Lutheran* decision was widely misinterpreted as holding that floodplain regulations were, in general, unconstitutional, or that the specific regulations addressed by the Court were unconstitutional. In reality, the Court carefully stated <u>that it was not deciding the constitutionality of the floodplain regulations</u>,[4] and suggested that sound grounds for the regulations might well exist. The Court only held that, as a matter of law, temporary damages would be available if a taking had occurred. The Court sent the case back to the lower courts to decide whether a taking had, in fact, occurred.

Although the decision did not invalidate any regulations, it did establish, as a matter of principle, that governments would need (at least in some situations) to pay temporary damages for regulations that were in fact a taking.

Shortly after issuing the *First Lutheran* decision, the U.S. Supreme Court issued a third decision — *Nollan v. California Coastal Commission*.[5] Here the Court held that the efforts of the California Coastal Commission to require that a beachfront property owner convey a beach access easement as a condition to receiving a permit for rebuilding a structure was a taking. The Court did not disapprove the condition but rather felt that the Commission had not adequately demonstrated that the condition "substantially advanced" state interests. The Court emphasized the need for a regulatory agency to show a reasonable nexus between a regulation and stated goals.

Collectively, how are these three Supreme Court decisions cases likely to affect floodplain management?

The cases pertain almost entirely to regulations, not to other floodplain management techniques. The cases indicate the willingness of the Court to strongly support hazard-related regulations if they are soundly based in fact, even if the regulations substantially reduce property values or prohibit use of a portion of a property. But the decisions also affirm that governments must pay for a temporary taking of property if, in fact, their regulations "take" property. The basic tests for taking, described later in this chapter, are apparently unaltered by the decisions. The latter two cases (*First Lutheran* and *Nollan*), however, also suggest an increasing willingness of the Court to examine the factual basis for regulations and the relationship of particular standards to regulatory goals.

Since these 1987 Supreme Court cases, federal and state courts have considered the constitutionality of floodplain regulations in at least seven cases. The regulations have been upheld in all cases,[6] including a follow-up California court decision in *First Evangelical Lutheran Church v. County of Los Angeles* which was remanded by the Supreme Court to the California Court.[7] In this follow-up decision, the California court resoundingly endorsed the floodplain regulations and held that the regulations were not a taking of private property.

CONSTITUTIONAL CHALLENGES: THE BROADER CONTEXT

How have regulations and other flood loss reduction measures fared in the broader context when challenged as unconstitutional in state and federal courts? In general, they have fared very well as flood hazard regulations have been broadly and consistently upheld (Kusler, 1982). Regulations have, however, been challenged as unconstitutional violations of guarantees of Due Process and unconstitutional takings of private property without payment of just compensation. Constitutional challenges have been raised on a number of grounds, including: inadequacy of statutory powers; invalid objectives; failure to comply with statutory procedures; discrimination; unreasonableness; or taking of property without payment of just compensation.

Inadequacy of Statutory Powers

In the early years of floodplain management, the adequacy of local zoning, subdivision control, building code, and other enabling statutes to authorize local government or agency adoption of floodplain regulations was often questioned, particularly where the legislature had not expressly authorized local governments to adopt regulations (Kusler, 1982; Strauss, 1976).

These challenges of floodplain regulations were based upon a general rule of law that federal and state agencies and, to a lesser extent, local governments, may exercise only those powers specifically delegated to them by statute. In other words, an agency or local government is able to adopt floodplain regulations only if a statute specifically authorizes such regulations. Otherwise, the regulations violate Constitutional requirements of Due Process.

Although a number of challenges were made, the basic authority of local governments to regulate floodplains under general zoning or other land-use control statutes was sustained in all cases (Kusler, 1982). As a result, lack of adequate local enabling authority is no longer a common legal challenge except in those instances where: 1) units of government wish to regulate extraterritorially and they are not authorized to do so; or 2) statutes provide specific exemptions (e.g., nonconforming uses) and an attempt is nevertheless made to regulate exempted uses. Lack of enabling authority is also a diminished problem, in part, because most states have granted cities and some counties and towns broad statutory or constitutional "home rule" powers (Strauss, 1976). Home rule governments can undertake a broad range of regulatory, acquisition, flood control, evacuation, and other public safety and general welfare activities without specific enabling legislation.

Very few court decisions in the last two decades have dealt with the adequacy of enabling powers for state or federal floodplain management measures because state and federal agencies are usually sensitive to limitations upon statutory powers. Also, courts tend to broadly interpret powers where issues of health and safety are involved.[8]

Invalid Objectives

Over the last two decades, courts have afforded legislative bodies broad discretion in defining public objectives for regulations, acquisition, and other hazard-reduction approaches.[9] Protection of public safety and reduction of flood losses have repeatedly been recognized[10] as valid public objectives for regulatory and nonregulatory measures (Kusler, 1982).

Courts have examined the objectives of floodplain regulations more carefully than the objectives of nonregulatory flood loss reduction techniques. Although courts have rarely invalidated hazard-related regulations for invalid objectives, some zoning regulations adopted primarily to lower the cost of land acquisition have been held invalid.[11]

Failure to Comply with Statutory Procedures

In general, courts demand that governments closely comply with statutory procedures in order to meet Due Process requirements. In a few cases, courts have held that flood hazard regulations were invalid in their entirety or as they applied to particular lands because the regulatory agency failed to follow statutory procedures for mapping, notice and hearing, or other matters.[12]

Perhaps the largest number of cases dealing with statutory procedures has involved challenges to federal or federally funded flood control works or other public works based on inadequate environmental impact statements. Courts have held that the National Environmental Policy Act requires careful consideration of environmental values but that the ultimate decision with regard to location and project design is up to the agency.[13]

Courts have also considered the adequacy of federal agency actions in complying with the Floodplain Management and Protection of Wetlands Executive Orders (E.O.s 11988 and 11990, respectively) in several cases.[14]

Discrimination

Very few successful challenges have been made to regulations based upon claims of discrimination, although an early challenge to an encroachment line was sustained.[15] Also, a federal district court in Ohio recently held that certain floodway restrictions were invalid because activities posing similar threats to health and safety were not regulated in another area of the community.[16]

Unreasonableness

A number of suits have been brought in the last two decades challenging the reasonableness of regulations in achieving specific regulatory objectives (U.S. Water Resources Council, 1971, 1972; Kusler, 1982). Courts have broadly supported agency or legislative rules or regulations or case-by-case permit evaluations against claims of unreasonableness. Renewed challenges to regulations based upon claims of unreasonableness, however, are likely as the result of the Supreme Court's decision in *Nollan v. California Coastal Commission*.[17] In this decision, the Court apparently endorsed a higher standard for reasonableness — in those instances where a taking is alleged — than was formerly required. This case, however, did not involve a natural hazard situation.

Mapping Inadequacy

Landowners have occasionally contested the accuracy and scale of federal, state or local flood maps. Mapping efforts, however, have been broadly sustained, even when some inaccuracies are found, provided that the regulatory agency has established administrative procedures for dealing with inaccuracies.[18] Some maps applying to particular properties have been held inadequate where gross errors were identified or statutory procedures were lacking.[19]

Prohibiting Particular Types of Activities in Floodways or Flood Fringe Areas

In a small number of cases, landowners have contested the prohibition of particular activities in floodways or flood fringe areas. A prohibition of residences in floodways by the Washington Department of Ecology was upheld by the Washington Supreme Court.[20] Similarly, the Iowa Supreme Court upheld an order of the Iowa Natural Resources Council requiring the removal of condominiums illegally placed in a floodway.[21]

Taking of Private Property Without Payment of Just Compensation

With the exception of a few cases in which regulations prevented all economic use of floodplain property, courts have upheld the general validity of floodplain regulations against claims that such regulations take private property without payment of just compensation (Kusler, 1982). These rulings are consistent with a much larger body of cases in which courts have broadly upheld land use regulations against claims of taking, despite the impact of the regulations upon property values.

In the broader context of land use controls, courts commonly uphold the general validity of a regulation (e.g., an agricultural zoning district that restricts residential development) but may hold that the regulation takes private property when judging its impact on a particular parcel. This site-specific determination of taking is based upon the consideration of a broad range of factors, including: the goals of the regulation; the public need for the regulation; the adequacy of the factual base supporting the regulation; the activities currently being carried out on the land or potentially available pursuant to the regulation; the economic value of the activities to the private property owner, the cost of purchase of the land; the expectations of the landowner at the time of purchase; and whether these expectations were consistent with the regulations.

Although courts in broader contexts have often upheld the validity of regulations in general, but have judged some regulations as takings with respect to particular property, the courts have almost universally sustained floodplain regulations both in general and as applied to specific property. There are several reasons for this support of floodplain regulations.

- FIRST, the rights of private landowners in water-oriented lands (e.g., floodplains and wetlands) are subject to "public trust" and "navigable servitude" rights and interests.[22]
- SECOND, courts give great weight to protection of public health and safety and have, without exception, sustained regulations needed to prevent nuisances[23] (e.g., blockage of flood flows) and to prevent private actions (e.g., construction of dams) that may threaten public or private safety on other land.
- THIRD, courts have, over the last twenty years, broadly upheld performance standard regulations like the floodplain regulations typically adopted by states and local governments that require private landowners to protect floodway conveyance capacity and elevate or otherwise protect structures to the 100-year flood elevation.
- FOURTH, courts have broadly supported technically-based regulations adopted consistent with a federal/state/local overall plan and standards (e.g., pollution controls; state and local floodplain regulations adopted pursuant to the National Flood Insurance Program).[24]

How will the three recent U.S. Supreme Court decisions affect future rulings on the "taking" issue? Performance standard approaches and other regulatory approaches that tightly control only portions of properties are not likely to be affected by these decisions and gain support from the *Keystone* decision. Although the recent Court decisions have apparently not affected the basic tests for determining if a taking has occurred, governments will now need to pay "temporary damages" if a court determines that a taking has occurred. Some state courts had already awarded temporary damages for regulatory takings prior to this decision, but most had not. Unfortunately, the Court did not determine when a temporary taking would commence, under what precise circumstances a temporary taking would occur, and what the measure of damages should be. A reading of the *Keystone* and *First Lutheran* decisions together suggests a continuation of the overall rule for determining whether a taking has occurred — in general, no taking occurs unless an entire property is denied all reasonable, economic use. Even then, a taking may not occur if all economic uses are nuisance-like or threaten public safety (Kusler, 1982).

COURT FINDINGS ON FLOODPLAIN MANAGEMENT MEASURES

A more specific examination of cases addressing the taking issue over the last twenty years indicates a number of important findings concerning several types of floodplain management measures.

Setbacks

Courts have upheld ocean and river setback standards (e.g., distances that development must be set back from the water's edge) (Pupula, 1974; O'Donnell, 1976; Maloney, 1978) to reduce flood and erosion damage in a number of cases, including a Florida decision that broadly endorsed setbacks to reduce hurricane and flood damage.[25] A recent lower court decision in South Carolina that found a setback standard to be a "taking" was overturned on appeal.[26] In general, setbacks affect only portions of properties and, therefore, do not deny all economic use of entire properties. Most setback standards would not be affected by the recent U.S. Supreme Court decisions.

Moratoria

A number of courts have sustained fixed-period moratoria on rebuilding after flood disasters.[27] However, as noted previously, the U.S. Supreme Court in the *First Lutheran* decision held that the moratorium on rebuilding adopted by Los Angles County might be considered a taking if it prevented all economic use of the land.

Although the *First Lutheran* decision raises questions concerning the validity of certain moratoria, it should not affect soundly based moratoria imposed for fixed and relatively short periods of time.

Regulations Preventing All Development in Floodways and/or Flood Fringe Areas

A number of state courts[28] have upheld very tight restrictions on floodway uses against claims of taking. Apparently, no court has held that such regulations are a taking.

In the last decade, a number of courts have upheld open space regulations applied to broader floodplain areas.[29] Several earlier decisions, however, held that open space regulations were a taking because they denied all economic use of the lands affected.

The recent U.S. Supreme Court decisions will probably not affect regulations preventing development in floodways and/or flood fringe areas although courts may now examine open space regulations with greater care.

Subdivision Regulations

Courts have broadly endorsed regulations controlling the subdivision of floodprone lands[30] and requiring that subdividers install storm drains and on-site flood detention areas. Courts have also endorsed drainage fees and other types of exactions as long as the fee or exaction had some relationship to, and was proportional to, the special problems or needs of the subdivided area. For example, a subdivider can be required to install a storm drain to meet the needs of a subdivision but may not be required to install or pay for a storm drain for the whole community.

The recent U.S. Supreme Court decisions will likely not affect subdivision approval requirements although courts may now require, in light of the *Nollan* decision, that governments more clearly justify conditions attached to subdivision approval and more carefully relate those conditions to the goals of regulations.

Regulation of Nonconforming Uses

Efforts to prohibit the rebuilding of nonconforming uses after flood disasters have been very carefully examined by courts in the last ten years due, perhaps, to the severe nature of these restrictions. For example, the South Dakota Supreme Court[31] held that efforts by Rapid City to summarily raze structures damaged by the Rapid City flood of 1972 without payment of compensation were a taking of property. This decision was based on the inadequacy of the procedures applied by the City and the lack of documentation that these structures were nuisances in fact. The Minnesota Supreme Court[32] also held that circuitous but persistent regulatory efforts to prevent a landowner from repairing a structure after a severe flood were a taking. As noted previously, the U.S. Supreme Court in *First Lutheran* decided that a moratorium on rebuilding after a flood disaster might be a taking.

These cases do not suggest that reasonable regulation of nonconforming uses before or after a disaster will be held a taking, only that very stringent regulations lacking adequate factual base and not tailored to the circumstances may be considered a taking in some circumstances.

Sand Dune Protection Regulations

Several state courts held in the 1970s and early 1980s that highly restrictive regulations prohibiting all alteration of sand dunes were a taking because they denied all economic use of entire properties.[33] However, the Maine Supreme Court recently upheld a dune protection regulation that allowed temporary, seasonal use of "back dune" areas for recreational vehicles but prohibited permanent structures.[34] The temporary, seasonal use was considered a reasonable use for the property.

Wetland Regulations

State courts have broadly endorsed state and local wetland regulations during the last ten years (Kusler, 1982).[35] Federal district courts and appellate courts in dozens of cases have also sustained denial by the U.S. Army Corps of Engineers of applications for Section 404 permits.[36] In 1985, the U.S. Supreme Court unanimously endorsed the permitting requirements established under Section

404 of the Clean Water Act, but warned that such regulations might take private property where regulations prevent all economic use of whole properties.[37]

State and federal courts have also endorsed regulations to protect the natural and cultural resources, including environmental and aesthetic values, of floodplain areas.[38] A number of court-supported regulations and/or programs that serve to protect natural and cultural floodplain resources, however, have been established for the primary purpose of reducing flood losses.

LIABILITY FOR FLOOD DAMAGES

The threat of liability is an important concern affecting the implementation of certain floodplain management measures by government agencies. In contrast with only a handful of lawsuits nationwide over the last twenty years that have successfully challenged government flood loss reduction actions on constitutional grounds, landowners have won thousands of damage suits against government units for causing or increasing flood damages. Most of these successful lawsuits have been based on various common law grounds for liability such as nuisance or trespass. Some have also been based on constitutional grounds such as taking of private property without payment of just compensation.

A property owner or other individual suffering a flood or drainage-caused loss can recover damages from a government unit in court only if the owner can show that: 1) the government entity owed a duty to the owner or individual to avoid, prevent, or mitigate such loss; 2) the entity failed to carry out that duty; and 3) the owner or individual suffered damage as a result of this failure.

The government entity charged with failure to carry out a duty may defend itself by claiming: 1) no duty existed; 2) there was no failure to carry out the duty if one existed; 3) the landowner or other property owner was not damaged, as claimed, by the failure to carry out a duty; or 4) other defenses exist to the suit such as sovereign immunity, contributory negligence, or expiration of the statute of limitations.

REASONS FOR INCREASED LITIGATION

Successful "liability" suits for increased flood damages have increased in recent years for the following reasons:

- Landowners suffering flood damages have been encouraged to initiate legal actions by the prospect of large damage awards from juries and the willingness of lawyers to take such suits on a contingent fee basis. Units of government have also often been viewed as having "deep pockets" (i.e., the ability to pay large awards).
- Courts have recognized broadened concepts of public and private landowner responsibility. For example, the "common enemy doctrine" whereby landowners may alter or increase the flow of diffused surface waters even where such alteration damages other landowners has been judicially modified in many states to a rule of "reasonable use." Under a reasonable use doctrine, landowners can modify natural drainage only if they do so "reasonably" with regard to impact

on others. In general, actions that substantially damage other landowners are not considered reasonable by the courts.

- The "act of God" defense pertaining to damages from natural hazards has been severely diminished by improved flood prediction capability and flood maps. In the past, a private landowner or unit of government blocking a floodway with a dike, for example, might have escaped liability for increased flood damage on other property from a "100-year" flood by claiming the flood was an "act of God."[39] Such a defense, however, requires not only that a flood event be very large and infrequent but that it be unforeseeable. Widespread availability of flood maps and improved flood prediction make even standard project floods foreseeable.
- Improved data bases (stream flow records, flood maps) and hazard modeling capability have facilitated proof of causation and proof of damages. Twenty years ago it was difficult to prove that a fill in a floodway had raised flood heights one foot. Today, models are readily available to calculate the impact of a fill on a specific size flood (e.g., a "100-year" flood).
- Improved technology, broad-scale dissemination of such technology, adoption of regulations and guidelines, and the application of improved technology at many hazard locations have created an increasingly high standard of care for "reasonable" government action. In general, governments are only liable for increased flood damages when government units do not exercise reasonable care. Reasonableness depends upon the technology available, regulatory requirements, area customs, and a variety of other factors.
- The "sovereign immunity" defense[40] of states, local governments and, to a lesser extent, the federal government has been substantially modified by statutes and case law, making it now possible for landowners to sue government entities for a wide range of activities including grading, filling, road-building and other activities that may interfere with drainage and flood loss reduction measures such as dikes, dams, levees, and flood warning systems.

FACTORS AFFECTING LIABILITY

A number of additional considerations affecting government liability are of interest to floodplain managers.

Government Liability When No Action is Taken

Except in a few instances, governments are not liable for naturally occurring flood damages.[41] Government has, in general, no duty to construct dams, adopt regulations, or carry out other hazard reduction activities unless required to do so by a statute. It is only where a government unit causes flood damages or increases natural flood damages that liability may arise.

As a result, some government attorneys have recommended, in some instances, that agencies or local governments "do nothing" with regard to flood loss reduction as a way of reducing potential liability. This is increasingly poor advice. Although a common law duty to act may not exist, state legislatures and Congress are requiring agencies and local governments to undertake certain hazard-reduction measures which, if not carried out, may lead to liability. In addition, thousands of local governments have adopted floodplain ordinances that establish specific procedures and standards for activities in floodplains and for evaluating permit applications for floodplain use. Failure to comply with statutes or ordinances may also result in liability.[42]

As a practical matter, it is often impossible or impractical for a city or state to "do nothing" with regard to hazard areas in order to avoid liability. Cities have usually already undertaken a broad range of activities that may increase natural flood damages on private property. These activities include construction of roads and bridges, storm drains, dikes and levees, sewage treatment and water supply plants, and various public buildings in the floodplain. Given the high risk of liability associated with these activities, it may be far more appropriate to install a flood warning system with the slight chance that liability may result if the system is incorrectly designed or maintained than it is to face unmitigated flood damages resulting from the earlier activities.

Strict Liability Versus Reasonableness

In general, government units are not "strictly or absolutely" responsible for increased flood damages. Liability usually results only where[43] there is a lack of reasonable care. In some jurisdictions, however, a concept of strict liability has been applied with respect to dams because of the high probability of serious damage from dam failures (Bender, 1979).

Where the standard of reasonable care is judicially applied to an activity, the seriousness of foreseeable threat to life or economic damage is an important factor in determining reasonableness of conduct.[44] In general, the more serious the anticipated threat, the greater the care the government entity must exercise. (See the later section in this chapter on "vertical evacuation.")

Policy or Discretionary Decisions Versus Nondiscretionary, Ministerial Actions

As a general rule, courts do not hold legislative bodies or administrative agencies liable for policy decisions[45] or errors in judgment where the legislature or agency exercises policy-making or discretionary powers. But they often hold agencies responsible for failure to carry out nondiscretionary duties or for negligence in carrying out ministerial actions. For example, an agency decision to build a bridge able to convey "100-year" flood flows rather than "500-year" flows will probably not result in liability despite damage to upstream landowners when a "500-year" flood occurs. This decision is discretionary — it involves judgment and the balancing of costs and other factors. In contrast, that same agency's failure to build or maintain the bridge consistent with sound engineering practices (a ministerial function) could result in liability.

Liability of Government Employees

Although governments may be liable for increased flood or drainage losses in a broad range of contexts, government employees are usually not personally liable for planning, permit issuance, operation of dams, adoption of regulations, or other activities. Legislators enjoy almost absolute immunity.[46] Agency staff are also protected, but not to the same extent. No personal liability results where a government employee acts in good faith, within the scope of his or her job, and without malice. Successful lawsuits for hazard-related damages against government employees under common law theories or pursuant to Section 1983 of the Civil Rights Act are apparently nonexistent.

LIABILITY AND HAZARD REDUCTION ACTIVITIES

The potential for government liability differs depending upon the level of government involved. Liability also differs with regard to the following types of hazard reduction measures that may be carried out.

Flood Control Measures

Local and state governments have often been successfully sued for negligence in the construction, operation or maintenance of dikes, dams, levees, drainage ditches, and other flood control measures.

In contrast, the federal government is not liable for damages resulting from the design or operation of flood control facilities because Section 702(c) of the Flood Control Act of 1936[47] specifically exempts the federal government from liability for flood control measures. Nevertheless, landowners have often attempted to sue the federal government for negligent operation of flood control works. With minor exceptions,[48] however, courts have found no federal liability because of the Section 702(c) exemption.

Mapping

In several cases, landowners have attempted to sue the federal government for damages caused by inaccurate federal flood maps. So far, no suit has succeeded. In two cases, the court held that maps prepared by the Federal Emergency Management Agency were, in fact, flood control measures and subject to the broad federal flood control immunity.[49]

Landowners, however, have successfully brought cases against several states for disseminating inaccurate hazard information.[50]

Warning Systems

The adequacy of warnings and warning systems has been litigated in only a small number of cases although more such cases can be expected due to the establishment of a large number of warning systems and broadened concepts of government liability. In one decision, a federal court held that the federal government was not liable for an inadequate or inaccurate flood warning along the Missouri River.[51]

In a recent and widely publicized case, the U.S. Court of Appeals for the 1st Circuit[52] held that the National Weather Service (NWS) was not responsible for failing to provide a weather report warning ships of a quickly developing and very powerful hurricane. A NWS weather buoy had not been working at the time the NWS issued its weather report for the Georges Bank off the coast of

Massachusetts. Several boats and crewmen were lost. Relatives of the victims brought action in federal district court claiming that the NWS was negligent because of the inoperative buoy and the resulting lack of warning by the NWS. The District Court held that the NWS could be sued for negligence and a jury awarded damages. This decision was appealed to a federal appellate court. The appellate court held that there was no evidence the NWS would have issued a different report if the equipment had been working, and reversed the district court. Although the federal government won, the case suggests that federal liability could result if a flood warning system was not adequately maintained and lack of maintenance could be shown as the cause of an inadequate warning and subsequent damages.

Flood Insurance

Landowners insured by the National Flood Insurance Program (NFIP) have filed a relatively large number of suits claiming inadequate payment (Neubauer, 1988). In general, the suits have been of a technical nature, and have addressed the precise terms of the insurance contract, including compensable types of losses (e.g., flood vs. landslide), compensable items (e.g., rugs vs. structure), and levels of compensation.

Some flood insurance-related suits have been broader-based and of greater overall significance with regard to floodplain management. For example, a federal court in one case held that landowners and communities have no right to flood insurance and can not claim that denial of such insurance was a taking of property.[53]

Disaster Assistance

The provision or absence of disaster assistance has not resulted in much litigation since courts have held that the disaster assistance statutes do not, in general, create any "rights" to disaster assistance.

Evacuation Planning

Apparently no court has considered the adequacy of particular evacuation plans or the community, federal, or state efforts to carry out such plans. A court would likely afford a government unit broad discretion without liability in the preparation of evacuation plans. There is a risk of liability, however, with respect to plan implementation. Successful law suits against communities by or on behalf of individuals injured or killed by police vehicles or ambulances involved in more routine emergency services suggest that communities could similarly be held liable for negligence in carrying out emergency evacuation activities. The test for reasonableness, however, would be reasonableness in the emergency context, not under ordinary circumstances.

Vertical Evacuation (Refuge)

Potential federal, state, or local liability for designation of structures as "vertical refuges" during a flood or hurricane has been broadly debated in recent years. This potential liability has also been addressed in a recent study (Ruch and others, 1991).

The potential for liability is significant in some respects because loss of life is likely if a structure designated as a vertical refuge should fail during a severe storm. There would be no way to escape a collapsing structure surrounded by water at the height of a storm. As noted previously, the degree of care that private individuals or governments must exercise to act "reasonably" in a specific circumstance depends, in part, upon the degree of risk present. Liability for loss of life or damages that might result from vertical refuge failure, however, depends on a broad range of other factors.

Clearly, private developers who promote new residences as "hurricane proof" or safe for use during a hurricane could be held liable if the structures failed during a hurricane.[54] Occupants (or, more likely, their decedents) could claim they were induced to buy the structure based on this assurance, and that an express or implied contract existed between seller and buyer.

A very different liability situation, however, would exist if a government unit merely designates certain buildings as possible refuges of last resort should evacuation become impossible, and warns that such designation provides no guarantee of safety. In this instance, there would be no express or implied contract and the government unit could only be held liable for negligence in designating the structure.

AVOIDING LEGAL PROBLEMS

As the threat of liability has increased, along with fears that flood loss reduction measures may be judged as a taking of property, some government units have undertaken measures to reduce potential legal problems. The extent to which such precautionary measures have been undertaken, however, is unclear.

AVOIDING CONSTITUTIONAL PROBLEMS

A number of measures have been taken to reduce the constitutional challenges to floodplain regulations and other loss reduction measures.

- Instead of prohibiting all activities in hazard areas, many states and local governments have adopted regulations with stringent performance standards. These standards often exceed the minimum NFIP standards. For example, Wisconsin has adopted a zero-rise floodway standard to prevent any significant increase in flood heights. It is extremely unlikely that such a performance standard approach based on a sound and uniformly applied concept of hazard reduction would be held as a taking.

- Many states and local governments have mapped floodplains in greater detail and with greater accuracy than the NFIP. Detailed and accurate maps reduce the possibility of successful constitutional challenges based on claims of unreasonableness or taking.
- Many local governments have provided real estate tax breaks for tightly controlled land. Coordination of regulatory, tax, acquisition, public works, and other community programs to diminish the financial burden on tightly regulated landowners makes good sense from a constitutional perspective.
- Many communities have adopted improved permitting and record-keeping procedures, including relatively detailed statements of findings for permit denials, so that these communities are better able to defend their positions if challenged in court.

AVOIDING LIABILITY DUE TO INCREASED FLOOD DAMAGES

Communities are also taking actions to reduce potential liability for flood damages or to reduce the impact of liability suits.

- Many communities, state agencies, and federal agencies are obtaining legal advice for avoiding future problems. This advice may pertain not only to what the agencies do but how they do it. For example, from a legal perspective it may be desirable to submit proposed standards for bridge openings, stormwater design, and flood protection elevations to a community's legislative body (e.g., city council) for debate and approval. Due to the special way legislative decisions are treated by the courts, legislative judgments, particularly those of a discretionary nature, are less likely to result in a successful liability suit than are agency decisions. Courts generally defer to legislative judgment.
- Some communities are preparing comprehensive flood hazard reduction plans and implementing such plans with the philosophy that "liability can be avoided if flood damages are avoided." From a legal perspective, this is a sound philosophy. Regulations that prohibit private landowners from increasing flood or drainage problems on land owned by others are virtually certain to be upheld in court and may help to avoid future lawsuits against the municipality (which is often viewed as having a deep pocket even if it is not principally responsible for flood damages).
- Communities have enrolled in the NFIP to avoid liability because they have learned that landowners are much less likely to sue for flood damages if the landowners have insurance and are quickly compensated for such damages.
- Many communities are adopting drainage plans and regulations as well as flood hazard reduction plans and regulations. To do so, they are adopting stormwater and grading ordinances as well as stormwater and drainage systems. Most of the suits against cities for flood problems are, in fact, for damages due to interference with natural drainage.
- Communities are avoiding hazard-prone locations for public works such as schools and libraries or quasi-public works such as industrial parks where users or lessees may be damaged by flooding.
- Agencies and communities are operating and maintaining dikes, levees, channels, flood warning systems, and other flood loss reduction measures with greater care to avoid claims of negligence.

- Communities are designing public works including roads, sewers, bridges, and sewage treatment plants so that these works comply with federal, state and local floodplain guidelines and regulations and so they do not block flood flows or cause drainage problems.
- Communities are applying remedial flood loss reduction measures to reduce the vulnerability of existing floodprone development, particularly where some of the flood hazard has been caused by government activities. These remedial measures may include acquisition and relocation, establishment of flood warning systems, construction of flood control works, and enlargements for bridge opening and culverts.
- Communities are purchasing liability insurance or establishing self-insurance pools or plans.

SUMMARY AND CONCLUSIONS

Litigation concerning government flood loss reduction measures takes two principal forms: 1) "constitutional" challenges to floodplain regulations and other loss reduction measures; and 2) "liability suits" initiated by those suffering flood losses as a result of incorrectly designed, maintained or administered flood loss reduction measures.

The legality of various public flood hazard reduction measures and the threat of successful claims for damages against government agencies for such measures are of concern to floodplain managers at all levels of government. This concern has developed as a result of many court decisions in recent years holding government agencies liable for actions that increased flood damages, and as a result of a small number of successful lawsuits challenging the constitutionality of land-use regulations.

The types of lawsuits and the specific issues litigated have changed over the last twenty years, reflecting changes in the predominant floodplain management techniques in use and the general status of constitutional and tort (liability) law, as well as unresolved legal issues associated with flood loss reduction techniques.

Three U.S. Supreme Court cases decided in 1987 addressing the constitutionality of specific land-use regulations were widely, but inaccurately, reported to have invalidated hazard reduction regulations. Although the three decisions are not easy to reconcile or interpret, and raise a number of additional legal questions, they pertain almost entirely to regulations (not to other floodplain management techniques) and do not generally invalidate hazard reduction regulations that are soundly based.

From a constitutional perspective, floodplain managers can continue to have confidence that performance-oriented floodplain regulations (e.g., building codes, subdivision regulations, zoning regulations) will be upheld in the courts despite restrictions that may affect private property owners in some instances. It is important, however, that certain guidelines be followed in formulating and implementing these regulations to reduce potential legal problems and lessen the risk of constitutional challenge.

From a liability perspective, floodplain managers should also have confidence that carefully prepared flood loss reduction measures will reduce community and state liability. Specific actions suggested in this chapter can be taken to further reduce potential government liability.

CITATIONS

1. See, e.g., *Morris County Land Improvement Company v. Township of Parsippany-Troy Hills*, 193 A.2d 232 (N.J., 1963); *Dooley v. Town Plan and Zoning Commission*, 197 A.2d 770 (Conn., 1964).

2. 107 S. Ct. 1232 (1987).

3. 107 S. Ct. 2378 (1987).

4. Chief Justice Rehnquist, speaking for the Court noted:

   "We accordingly have no occasion to decide whether the ordinance at issue actually denied appellant all use of its property or whether the county might avoid the conclusions that a compensable taking has occurred by establishing that the denial of all use was insulated as part of the State's authority to enact safety regulations."

5. 107 S. Ct. 3141 (1987).

6. See *Adolph v. Federal Emergency Management Agency*, 854 F.2d 732 (5th Cir., 1988); *April v. City of Broken Arrow*, 775 p.2d 1347 (Okla., 1989); *Reel Enterprises v. City of LaCrosse*, 431 N.W.2d 743 (Wis., 1988); *American Cyanamid v. Dept. of Envir. Prot.*, 555 A.2d 684 (N.J., 1989); *First English Evangelical Lutheran Church v. County of Los Angeles*, 258 Cal. Rptr. 893 (Cal., 1989); *Armonas v. Pratt*, 526 N.Y.S. 2d 511 (N.Y., 1988); *Terner v. Spyco, Inc.*, 545 A.2nd 192 (N.J., 1988).

7. *First English Evangelical Lutheran Church v. County of Los Angeles*, 258 Cal. Rptr. 893 (Cal., 1989).

8. See, e.g., *Maple Leaf Investors, Inc. v. State of Washington, Department of Ecology*, 565 P.2d 1162 (Wash., 1977).

9. See, e.g., *Berman v. Parker*, 348 U.S. 26 (1954).

10. See many cases cited in *Keystone Bituminous Coal Association v. DeBenedictis*, 107 S. Ct. 1232 (1987).

11. See, e.g., *Burrows v. City of Keene*, 432 A.2d 15 (N.H., 1981). But see *County of Ramsey v. Stevens*, 283 N.W.2d 918 (Minn., 1979).

12. See, e.g., *Morland Development Co. v. City of Tulsa*, 596 P.2d 1255 (Okl., 1979). See also *Hirsch v. Maryland Department of Natural Resources*, 416 A.2d 10 (Md., 1980).

13. See generally, *Homeowners, Emergency Life Protection Committee v. Lynn*, 432 F. Supp. 1334 (1977); but see *Texas Committee on Natural Resources v. Marsh*, 736 F.2d 262 (1984).

14. See, e.g., *Bergen County v. Dole*, 620 F. Supp. 1009 (1985); *Savia v. U.S. Postal Service*, 659 F. Supp. 653 (1987).

15. *City of Welch v. Mitchell*, 121 S.E. 165 (W. Va., 1924).

16. *Queen City Terminals, Inc. v. City of Cincinnati*, 666 F. Supp. 1035 (1987).

17. 107 S. Ct. 3141 (1987).

18. See, e.g., *Turnpike Realty Co. v. Town of Dedham*, 284 N.E.2d 891 (Mass., 1972); cert. denied, 409 U.S. 1108 (1973); *Just v. Marinette County*, 201 N.W.2d 761 (Wis., 1972).

19. See *Sturdy Homes, Inc. v. Township of Redford*, 186 N.W.2d 43 (Mich., 1971). See also *A.H. Smith Sand and Gravel Co. v. Department of Water Resources*, 313 A.2d 820 (Md., 1974).

20. *Maple Leaf Investors Inc. v. State of Washington*, 565 P.2d 1162 (Wash., 1977).

21. *Young Plumbing and Heating Co. v. Iowa Natural Resources Council*, 276 N.W.2d 377 (Iowa, 1979).

22. See, e.g., *Just v. Marinette County*, 201 N.W.2d 761 (Wis., 1972).

23. See many cases cited in *Keystone Bituminous Coal Association v. DeBenedictis*, 107 S. Ct. 1232 (1987).

24. See *Responsible Citizens in Opposition to the Floodplain Ordinance v. City of Asheville*, 302 S.E.2d 204 (N.C., 1983).

25. See, e.g., *Indialantic v. McNulty*, 400 So. 2d 1227 (Fla., 1981).

26. *Lucas v.South Carolina Coastal Council*, 403 S.E.2d 620.

27. See, e.g., *Lindquist v. Omaha Realty, Inc.* 247 N.W.2d 684 (S.D., 1976); *Cappture Realty Corporation v. Board of Adjustment of Elmwood Park*, 313 A.2d 624 (N.J., 1973).

28. See., e.g., *Foreman v. Department of Natural Resources*, 387 N.E.2d 455 (Ind., 1979); *Oswalt v. Ramsey County*, 371 N.W.2d 241 (Minn., 1985).

29. See, e.g., *Turnpike Realty Co. v. Town of Dedham*, 284 N.E.2d 891 (Mass., 1972), cert. den. 409 U.S. 1108 (1973).

30. See, e.g., *Brown v. City of Joliet*, 247 N.E.2d 47 (Ill., 1969); *Hamlin v. Matarazzo*, 293 A.2d 450 (N.J., 1972).

31. *Boland v. City of Rapid City*, 315 N.W.2d 496 (S.D., 1982).

32. *Oswalt v. Ramsey County*, 371 N.W.2d 241 (Minn., 1985).

33. See, e.g., *Lemp v. Town Board of Town of Islip*, 394 N.Y.S. 2d 517 (N.Y., 1977).

34. See *Hall v. Board of Environmental Protection*, 528 A.2d 453 (Me., 1987).

35. See, e.g., *Presbytery of Seattle v. King County*, 787 p.2d 907 (Wash., 1990); *J.M. Mills, Inc. v. Murphy*, 352 A.2d 661 (R.I., 1976); *Houslet v. State Dept. of Natural Resources*, 329 N.W.2d 219 (Wis., 1982); *Rowe v. Town of North Hampton*, 553 A.2d 1331 (N.H., 1989).

36. See generally William Want, 1990, *Law of Wetlands Regulation*, Clark Boardman Company, N.Y., N.Y. and the many cases cited therein.

37. See *United States v. Riverside Bayview Homes, Inc.*, 106 S. Ct. 455 (1985).

38. See, e.g., *County of Pine v. State, Dept. of Nat. Res.*, 280 N.W.2d 625 (Minn., 1979); *April v. City of Broken Arrow*, 775 p.2d 1347 (Okl., 1989).

39. See, e.g., *Barr v. Game, Fish, and Parks Commission of Colorado*, 497 P.2d 340 (Colo., 1972).

40. See, e.g., *County of Clark v. Powers*, 611 P.2d 1072 (Nev., 1980); *Enghauser Manufacturing Company v. Eriksson Engineering, Ltd.*, 451 N.E.2d 228 (Oh., 1983).

41. See, e.g., *Slemp v. City of North Miami*, 515 So. 2d 353 (Fla., 1987); but see *Sprecher v. Adamson Companies*, 636 P.2d 1121 (Cal., 1981).

42. See, e.g., *French v. City of Springfield*, 357 N.E.2d 438 (Ill., 1976); *Harvey v. Board of Commissioners of Wabash County*, 416 N.E.2d 1296 (Ind. App., 1981).

43. See cases cited in Annot. "Applicability of Rule of Strict or Absolute Liability to Overflow or Escape of Water Caused by Dam Failure," 51 A.L.R.3d 965 (1973).

44. See, e.g., *Laukkanen v. Jewel Tea Co.*, 222 N.E.2d 584 (Ill., 1966); *Ducey v. U.S.*, 830 F.2d 1071.

45. See e.g., *Valley Cattle Company v. U.S.*, 258 F. Supp. 12 (D.C., 1966).

46. See, e.g., *Lake Country Estates, Inc. v. Tahoe Regional Planning Agency*, 440 U.S. 391 (1979).

47. 33 U.S.C.A. 702(c). See, e.g., cases cited in noted 43, 45 infra.

48. See, e.g., *Price v. United States*, 530 F. Supp. 1010 (SD Miss., 1981).

49. *Baroni v. United States*, 662 F.2d 287 (1981); See also, Britt v. United States, 515 F. Supp. 1159 (1981).

50. See, e.g., *Connelly v. State*, 84 Cal. Rptr. 257 (Cal., 1970).

51. *National Manufacturing Co. v. U.S.*, 210 F.2d 263 (C.A., 1954).

52. *Brown v. U.S.* 790 F.2d 199 (C.A., 1986).

53. See, e.g., *Texas Landowners Rights Association v. Harris*, 453 F. Supp. 1025 (DC., 1978), affd. 598 F.2d 311 (1975), cert. den. 444 U.S. 927 (1929). See also *Responsible Citizens v. City of Asheville*, 302 S.E.2d 204 (N.C., 1983) and *Adolf v. FEMA*, 854 F.2d 732.

54. See, e.g., *Beri, Inc. v. Salishan Properties, Inc.*, 580 P.2d 173 (Ore., 1978); *McFeeters v. Renollet*, 500 P.2d 47 (Kan., 1972).

PART IV:

APPLICATION OF THE STRATEGIES AND TOOLS FOR FLOODPLAIN MANAGEMENT

This Part of the *Assessment Report* examines how and to what extent each of the strategies and tools identified in *A Unified National Program for Floodplain Management* are currently being applied. A separate chapter is devoted to each of the following basic strategies:

- Modifying Susceptibility to Flood Damage and Disruption
- Modifying Flooding
- Modifying the Impacts of Flooding
- Managing Natural and Cultural Resources

The strategies and tools are means for achieving compatibility between floodplain use, the risk associated with floodplain occupancy, and protection of floodplain resources. Choosing between alternative uses and activities in the floodplain is primarily a local decision that may result in single or multi-objective floodplain use, but this use should be compatible with the risk and with the natural and cultural values provided by floodplain resources.

CHAPTER 11:

MODIFYING SUSCEPTIBILITY TO FLOOD DAMAGE AND DISRUPTION

> *The range of possible adjustments which can be made to a hazard must be identified. It is rare that only one course of action is worthy of consideration.*
>
> White, et al. *Natural Hazard Management in Coastal Areas*, 1976

The strategy to modify susceptibility to flood damage and disruption consists of actions to avoid dangerous, uneconomical, undesirable, or unwise use of the floodplain.

> *These actions include restrictions in the mode and the time of day and/or season of occupancy; in the ways and means of access; in the pattern, density, and elevation of structures and in the character of their materials (structural strength, adsorptiveness, solubility, corrodibility); in the shape and type of buildings and in their contents; and in the appurtenant facilities and landscaping of the grounds. The strategy may also necessitate changes in the interdependencies between floodplains and surrounding areas not subject to flooding, especially interdependencies regarding utilities and commerce* (Federal Emergency Management Agency, 1986).

Specific tools to implement this strategy include:[1]

- floodplain regulations;
- development and redevelopment policies;
- floodproofing;
- disaster preparedness and response plans; and
- flood forecasting and warning systems.

[1] The 1986 edition of *A Unified National Program for Floodplain Management* lists "disaster assistance" under the strategy of modifying susceptibility to flood damage and disruption. For the purpose of this *Assessment Report*, disaster assistance is described in Chapter 13 as part of the strategy to modify the impacts of flooding.

FLOODPLAIN REGULATIONS

While the early history of floodplain management was dominated by structural flood control measures, the last 15 to 20 years can be characterized as an era of regulation. A substantial share of federal and state efforts, as well as local efforts, have been devoted to floodplain regulation over the last 20 years (Association of State Floodplain Managers, 1989). In the late 1960s, only a few hundred municipalities and counties had adopted floodplain zoning or flood-related subdivision regulations (Kusler, 1982). Since 1968 when the National Flood Insurance Act (NFIA) was passed, more than 16,000 communities have adopted some level of floodplain regulation as a result of their participation in the National Flood Insurance Program (NFIP). As a result, floodplain regulations are probably the most widespread floodplain management tool currently in use, and have a potentially greater impact on flood loss reduction than any other tool.

Floodplain regulation is primarily a local government responsibility, but generally states must enact enabling legislation to permit local governments and state agencies to exercise regulatory authority over floodplains.[2] Several states directly regulate some development in the floodplain (usually restricted to certain categories of development or development in specifically defined sections of the floodplain) and may regulate all floodplain development if a local government fails to act. Much of the impetus for state and local actions in floodplain regulation has come from the federal level.

Floodplain regulations may be used to: 1) control future development in floodplains; and 2) correct inappropriate development already in the floodplain. In practice, control of future development through regulations has proven much easier than efforts to remove or otherwise correct existing, inappropriate development.

LIMITATIONS OF FLOODPLAIN REGULATIONS

One consequence of the significant effort directed toward community adoption of floodplain regulations is that, to a large degree, floodplain management has become synonymous with floodplain regulation in the minds of many people — among both the general public and floodplain management professionals. A common misperception is that once floodplain regulations are adopted, a community's flooding problems will be largely solved. Due to the inherent limitations of floodplain regulations, however, and the manner and extent to which they are currently being implemented, regulations alone cannot provide a community or individual with full protection from future flood losses.

The principal limitations of floodplain regulations are associated with the following:

- Resistance to land-use regulations: Throughout much of the country, there remains widespread resistance to any type of land-use regulation. Floodplain regulations are perceived to restrict an individual's rights on privately owned property and to reduce property values. Not everyone is

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[2] In some states, municipalities and counties have "home rule" powers. "Home rule powers are usually considered 'residual powers' (not exercised by the state) which may be exercised by local legislative bodies to carry out municipal functions. In most instances, home rule powers are confined to matters of local concern" (Federal Insurance Administration, 1976).

convinced of the need for floodplain management, and some people particularly object to the use of regulations to help advance goals important to society (The Wildlife Management Institute, 1989).

- THE "TAKING ISSUE": Concern that regulations which may reduce the potential economic value of an individual's property will be ruled as an unconstitutional taking of property without proper compensation is a factor that keeps many communities from adopting more than minimum regulations. This is the case even if local officials perceive the need for stronger regulations (Bureau of Reclamation, 1989). Concern over the taking issue is widespread, even though courts have consistently upheld the validity of properly constructed floodplain regulations.[3]

- LACK OF EFFECTIVE ENFORCEMENT: Effective enforcement often requires greater training, personnel, and financial resources than many communities can provide.

> *. . . the main ingredient that would improve effectiveness of the [NFIP] program in [Los Angeles] is enforcement. We suspect this is a common obstacle to effective floodplain management throughout the nation. Although ordinances are adequate to define and pursue violations, the legal processes are time consuming and costly, and it is extremely difficult to continually observe the natural watercourses in order to detect these violations. The degree of effectiveness that would be satisfying in this area is not acceptable in terms of manpower commitment at this time. Therefore, the program operates on a random observation basis.* (Tidemanson, 1989).

- LIMITED IMPACT ON EXISTING BUILDINGS AND INFRASTRUCTURE: A fundamental limitation of floodplain regulations is their very limited impact on buildings and infrastructure already in the floodplain and subject to flooding. When the NFIA was enacted, it was anticipated that redevelopment would eventually result in removal or upgrading of the inventory of existing floodplain structures. This process appears to be slower than originally anticipated.

- REGULATIONS DO NOT PREVENT DEVELOPMENT IN FLOODPLAINS: Another limitation of floodplain regulations as currently employed is that they do not prevent development in floodplains. This, coupled with the failure to account for future development and resulting increases in flood levels (see below), will lead in the long term to increased flooding in many areas.

- REGULATIONS DO NOT TAKE INTO ACCOUNT FUTURE DEVELOPMENT: Most current floodplain regulations are based on the development and hydrologic conditions at the time of floodplain mapping, and do not take into account future development that will occur within and outside of the floodplain.

- REGULATIONS DO LITTLE TO PROTECT FLOODPLAIN NATURAL RESOURCES. Most floodplain regulations currently do little to protect the natural resources of floodplains. Only in coastal areas where regulations prevent sand dune and mangrove destruction that would increase flooding are natural resources specifically protected by floodplain regulations. To the extent that floodplain regulations allow development in floodplains — even though that development may not be subject to flood damage — the regulations can contribute to the loss of natural resources through the modification of

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[3] Refer to Chapter 10 for a review of court decisions relating to the taking issue.

wetlands and other wildlife habitat, and reduction in water quality caused by loss of stream buffers and introduction of various pollutants within the floodplain.

FEDERAL ROLE IN FLOODPLAIN REGULATION

House Document 465, *A Unified National Program for Managing Flood Losses*, noted the early efforts of the Tennessee Valley Authority (TVA) to encourage floodplain regulation in communities in the Tennessee Valley Region. Also noted were the efforts of the U.S. Army Corps of Engineers (Corps) to evaluate regulatory measures as an alternative to traditional, structural approaches in its flood information studies. Information, education, and technical assistance for floodplain regulation by both the TVA and the Corps have continued and remain strong components of the overall floodplain management programs of these agencies. Clearly though, the dominant federal role in regulatory actions to reduce flood losses throughout the 1970s and 1980s has been the National Flood Insurance Program as administered by the Federal Insurance Administration (FIA).

National Flood Insurance Program

The NFIP encompasses a broad range of activities that address many aspects of floodplain management. The following description of the NFIP is limited to the floodplain regulations that participating communities must adopt to be eligible for flood insurance. Flood insurance and other aspects of the NFIP are described in other sections of this chapter and in Chapter 13.

Although participation by local communities in the NFIP is voluntary, of 21,926 communities identified by the FIA as floodprone, 18,023 (82 percent) had joined the program as of September 30, 1990 (Matticks, 1990). Communities that participate in the NFIP in order to make flood insurance available within the community must enact floodplain regulations that, as a minimum requirement, meet standards established by the FIA. Minimum regulation requirements established by the FIA vary depending on the level of risk studies and mapping that have been prepared for the community. The FIA has developed several program activities to assist states and communities in adopting and complying with minimum floodplain regulations.

- **Emergency and Regular Phases.** The NFIP operates under two components: the emergency phase and the regular phase. Communities participate in the emergency phase before detailed risk studies have been completed. Once risk studies have been completed, or it is determined that detailed risk studies are not required because of low flood risk, communities are then converted to the regular phase of the NFIP. Of the 18,023 communities participating in the NFIP as of September 30, 1990, 17,743 (98.4 percent) were in the regular phase and 280 (1.6 percent) in the emergency phase (Matticks, 1990). The emergency phase of the program is scheduled to expire on September 30, 1991.

- **Flood Risk Studies and Risk Zones (Floodplain Mapping).** With congressional authorization through the National Flood Insurance Act, the FIA initiated a massive program to study and map the flood risk for each of the floodprone communities it has identified. The first flood risk map prepared for a community is the Flood Hazard Boundary Map (FHBM) which identifies flood hazard areas based on approximations of the land area in the community having a one percent or greater chance of being flooded in a given year. This initial map is usually followed by a detailed Flood Insurance Study (FIS) and a Flood Insurance Rate Map (FIRM) which identify the elevation of the one percent annual chance flood (referred to in the NFIP as the base flood) and the areas that would be inundated by that level of flooding. The FHBM and FIRM are used to determine areas subject to the floodplain regulations that participating communities must adopt.[4]

The maps designate areas subject to different types of flood risks. Table 11-1 shows the symbols and descriptions of the different risk zones used by the FIA in FHBMs and FIRMs. Floodplain regulations required by the NFIP are related to the risk zone as well as to the level of mapping completed. The zones subject to different types of regulations are: areas subject to a one percent annual chance flood (shown as an A, AE, AO, A99, AH zone); coastal high hazard areas subject to a one percent annual chance flood and wave action (shown as a V or VE zone); and designated floodways. Where floodways have been designated (floodways are not applicable in coastal high hazard areas), the portion of the floodplain outside the floodway is referred to as the floodway fringe. Figure 11-1 shows the relationship between the floodway, floodplain and floodway fringe areas. Other types of designated risk zones that the FIA has not yet applied are mudslide and flood-related erosion zones.

The FIA has developed or adapted several models and procedures to assess flood risks and delineate flood risk zones for different types of hazards. Several of the models and procedures have been modified to apply specifically to different geographic areas. Regulatory procedures provide for community and private input into the risk studies and maps prior to adoption. Amendment procedures are available to respond to inaccuracies and to make modifications based on changing conditions.

Mapping of flood hazard areas is acknowledged as a major accomplishment of the NFIP, with flood hazards identified for more than 18,000 floodprone communities. Criticisms of the mapping program have generally centered on the expense involved, the inaccuracies of some maps, failure to incorporate the effects of increased urbanization into the identified flood hazard areas, and the printing of maps in a format that is more useful for flood insurance agents and not just floodplain managers. Improvements with respect to most of these areas of criticism have been made over the past decade.

Most of the remaining concerns relate to: 1) the need for and costs (if left to communities) of remapping flood hazard areas to reflect local hydrology changes; and 2) the failure of maps to incorporate increased urbanization, and subsequently higher flood levels in future years. The FIA's decision not to reflect the effects of increased urbanization on floodplain maps is viewed by some as contributing to future flood damages (National Association of Flood and Stormwater Management Agencies, 1989).

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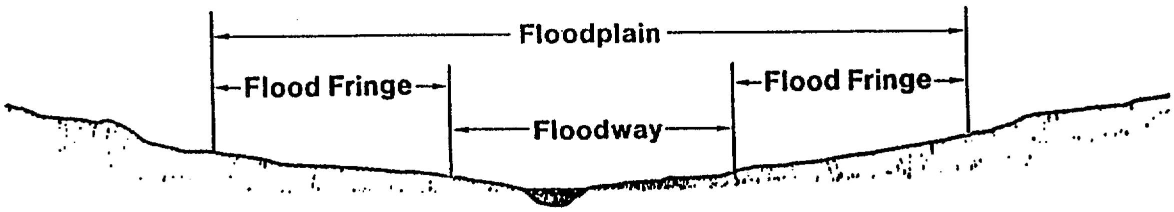
4 FIRMs are also used to determine flood insurance rates, as described in Chapter 13.

Table 11-1. Rate Zones Used in Flood Mapping Studies.

SYMBOL	DESCRIPTION
Special Flood Hazard -- Coastal High Hazard Areas	
V	Where water surface elevations have not been determined, subject to wave action, and are inundated by tidal floods (coastal high hazard area).
VE(a)	Where water surface elevations have been determined, subject to wave action, and inundated by tidal floods.
Special Flood Hazard -- Other than Coastal High Hazard Areas	
A	Where water surface elevation has not been determined.
AE(b)	Where water surface elevation has been determined.
AO	Where there are shallow water depths and/or unpredictable flow paths between (1) and (3) feet.
A99	Where enough progress has been made on a protective system (such as dikes, dams, and levees) to consider it complete for insurance rating purposes.
AH	Where there are shallow water depths and/or unpredictable flow paths between (1) and (3) feet, and where water surface elevations have been determined.
VO(c)	Where there are shallow water depths and/or unpredictable flow paths between (1) and (3) feet, and subject to wave action.
Little/Undetermined Hazard Areas	
X(d)	Area of moderate/minimal flood hazards.
D	Area of undetermined but possible flood hazard.
Special Flood-Related Hazard(e)	
E	Area of special flood-related erosion hazards.
Mudslide (mudflow) Areas(f)	
M	Area of special mudslide (i.e., mudflow) hazards.
N	Area of moderate mudslide (i.e., mudflow) hazards.
P	Area of undetermined, but possible, mudslide hazards.

(a) In older maps, these areas are designated by the symbol V1-30.
(b) In older maps, these areas are designated by the symbol A1-30.
(c) This symbol rarely used in mapping studies.
(d) In older maps, areas of moderated/minimal flood hazard were designated either by B (moderate hazard), or C (minimal hazard).
(e) To date the FIA has not used "E" symbol/designation in mapping studies.
(f) To date the FIA has not used these designations/symbols in mapping studies.

Source: Federal Emergency Management Agency, Federal Insurance Administration. Regulations implementing the NFIP 44 CFR 64.3.



Floodway Land Uses

Prohibited or Discouraged:
Most structures and fills.

Permitted:
Farming, pasture, forestry open space, recreation, wildlife preserves.

Flood Fringe Uses

Prohibited or Discouraged:
Storage of toxic materials.
Hospitals and other vital facilities.

Permitted:
All other uses with developments elevated on fill or otherwise protected against damage.

Floodplain regulation can be employed to limit uses in an area to those which are consistent with the flood hazard.

Source: Flood Loss Reduction Asociates. Floodplain Management Handbook. U.S. Water Resources Council, 1981.

Figure 11-1. Relationship Between Floodplain, Floodway, and Flood Fringe Areas.

- **Minimum Floodplain Regulations.** All communities participating in the NFIP must meet minimum floodplain management requirements that include:
    - implementing a permit program for all proposed new development;
    - reviewing subdivision proposals to assure that potential flood damage is minimized;
    - anchoring and floodproofing structures to be built in known floodprone areas;
    - safeguarding new water and sewage systems and utility lines from flooding; and
    - (in the regular phase only) enforcing risk zone, base flood elevations, and floodway requirements after the FIRM becomes effective.

The states are also required to meet minimum floodplain management requirements with respect to any state facilities located within a special flood hazard area. State facilities must comply with the floodplain management regulations of the community in which the facility is located, or with state standards approved by the FIA.

Numerous performance and specified standards applicable to each risk zone are detailed in FIA regulations. Some of the more critical requirements for communities participating in the regular phase of the NFIP are described on the following pages. The term "base flood" is generally used in the FIA regulations and is therefore used here instead of "one percent annual chance flood."

1) NEW DEVELOPMENT AND SUBSTANTIAL IMPROVEMENTS: Most regulatory requirements apply to new development and substantial improvements started after the date that the community's regulations are adopted. The FIA, the states, and the communities have all encountered difficulty interpreting and complying with the requirement regarding substantial improvement of structures. Community officials have particular concerns with respect to the issuance of permits for the repair of damaged structures following a serious flood or other disaster. Questions have arisen regarding what constitutes substantial improvement or substantial damage, who makes the determination, and the criteria for granting variances. The FIA has attempted to address these concerns by providing information to communities (Federal Emergency Management Agency, 1989), and by modifying the definitions of "substantial improvement" and "substantial damage." Current definitions as of October 1, 1989 are:

   "Substantial damage means" damage of any origin sustained by a structure whereby the cost of restoring the structure to its before damaged condition would equal or exceed 50 percent of the market value of the structure before the damage occurred.

   "Substantial improvement means" any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure before the "start of construction" of the improvement. This term includes structures which have incurred 'substantial damage', regardless of the actual repair work performed. The term does not, however, include either:

   (1) Any project for improvement of a structure to correct existing violations of state or local health, sanitary, or safety code specifications which have been identified by the local code enforcement officials and which are the minimum necessary to assure safe living conditions or

   (2) Any alteration of a "historic structure," provided that the alteration will not preclude the structure's continued designation as a "historic structure" (44 CFR, Section 59.1).

2) REGULATORY FLOODWAY: If a regulatory floodway has been delineated, no fill or development that would raise the base flood level is permitted within the area of the regulatory floodway that would raise the base flood level.

3) RESISTANCE TO FLOOD WATERS: All new construction and substantial improvements must be constructed: to prevent flotation, collapse or lateral movement of the structure; with materials resistent to flood damage; and by methods and practices that minimize flood damage. Also, electrical and other service facilities must be designed and located to prevent water from entering or accumulating within the components during flooding.

4) ELEVATION TO BASE FLOOD LEVEL: All residential structures must have the lowest floor (including basement) elevated to or above the base flood level. All nonresidential structures must have the lowest floor (including basement) elevated to or above the base flood level or, together with attendant utility and sanitary facilities, be designed so that below the base flood level the structure is water-tight and capable of resisting hydrostatic and hydrodynamic loads and effects of buoyancy.

5) ENCLOSED AREAS BELOW BASE FLOOD ELEVATION: These areas must be designed to allow for the entry and exit of floodwater to automatically equalize hydrostatic flood forces on exterior walls, and have electrical and other utility connections above the base flood level.

6) STRUCTURES IN COASTAL HIGH HAZARD AREAS: Specific requirements for all new construction or substantial improvement in coastal high hazard areas include:

   - All new construction or substantial improvement must be located landward of the mean high tide line;

   - All new construction or substantial improvements must be elevated on pilings or columns so that the bottom of the lowest supporting horizontal member is located at or above the base flood elevation;

   - All pilings and columns must be anchored to resist flotation, collapse, and lateral movement due to the effect of wind and water loads acting simultaneously on all building components. The design standard for water loads shall be the standard associated with the base flood, and for wind loads the standard required by applicable state or local building standards.

   - No fill may be used for structural support;

   - No alteration of sand dunes that would increase potential flood damage is permitted; and

   - Areas below the base flood elevation must be either free of obstruction or constructed with nonsupporting breakaway walls intended to collapse without causing structural damage to the elevated portion of the building or the supporting foundation system. Any enclosed space may be used only for parking of vehicles, building access, or storage.

- **Community Rating System.** From 1987 through 1989, the FIA developed and pilot-tested a Community Rating System (CRS). The goal of the CRS is to encourage, by the use of flood insurance premium adjustments, community and state activities that go beyond the basic NFIP requirements to:
  - Reduce flood losses;
  - Facilitate accurate insurance rating; and
  - Promote the awareness of flood insurance (Federal Emergency Management Agency, 1990).

  The CRS is the first positive incentive offered through the NFIP for communities participating in the program. The CRS will give communities "credit" for eighteen activities in the categories of "Public Information Activities," "Mapping and Regulatory Activities," "Flood Damage Reduction Activities," and "Flood Preparedness Activities." For example, Activity 430, "Higher Regulatory Standards," gives credit for community requirement of mandatory freeboard, regulation of cumulative substantial improvements, preservation of floodplain storage capacity and several other regulatory approaches.

The CRS was proposed for implementation during 1990, and the FIA expected to receive the first applications from communities by December 15, 1990. Communities that qualify will earn for their NFIP policy holders a 5% premium reduction on October 1, 1991, with additional reductions possible a year later. Ultimately, the CRS will reduce insurance premiums up to 45% for NFIP policy holders in communities where the minimum NFIP standards for floodplain land-use management are exceeded. Since the CRS is designed to be "revenue neutral," reduction in premiums reflects the reduced exposure to flood hazards and expected reductions in losses following a flood event.

The CRS is voluntary for communities, and is not intended to be prescriptive. Nevertheless, because floodplain management at the community level is so strongly influenced by the NFIP and its minimum requirements, it is expected that many communities will view the CRS's creditable activities as a complete list of worthwhile floodplain management activities. Even where states have more restrictive laws concerning floodplain development, communities see the NFIP as the primary requirement for most of their floodplain management activities.

The CRS has generated great interest, as well as some concern, among state and community floodplain managers. Communities that are already exceeding the NFIP minimum requirements for land-use management anticipate increased public support for their programs. Floodplain managers who have wished to improve their programs view the CRS as providing a political incentive for their elected officials to increase resources for floodplain management. Concerns have centered primarily on the likely inability of small and economically disadvantaged communities to participate in the program due to a lack of resources, including staff and funds to carry out many of the activities for which program credit is available.

- **FIA Assistance to States and Communities.** In addition to establishing minimum requirements for floodplain regulations and preparation of risk studies and maps, the FIA has undertaken several additional activities designed to assist states and communities adopt and enforce floodplain regulations. Major activities include:

  1) BIENNIAL REPORTS: Every other year, each participating community is required to submit to the FIA a report providing information on the number of permits and variances issued within the floodplain, and information on other aspects of community administration of floodplain regulations.

  2) COMMUNITY ASSISTANCE PROGRAM: The FIA has established a Community Assistance Program (CAP) intended to assure that communities participating in the NFIP are carrying out the flood loss reduction objectives of the program. This goal is achieved by providing needed technical assistance to NFIP communities, and by identifying and resolving floodplain management issues before they develop into problems requiring enforcement action. Two major components of the CAP are the Federal Agency Support Services Element (FASSE) and the State Support Services Element (SSSE). The FASSE is a partnership with allied government agencies through interagency agreements, while the SSSE uses cooperative agreements with state NFIP coordinating offices. The federal agencies and states provide specific floodplain management technical assistance activities to NFIP communities, as

negotiated with FEMA regional offices. Assistance activities correspond to the general areas of NFIP: ordinance development and administration, floodplain management education, information, and regulation. The single most important activity under the CAP is the Community Assistance Visit (CAV). A CAV is a scheduled visit to an NFIP community to conduct a comprehensive assessment of the local floodplain management program, and assist the community in implementing effective flood loss reduction measures.

3) TECHNICAL ASSISTANCE DOCUMENTS: The FIA has prepared and distributed, either directly or through state Flood Insurance Coordinator offices, numerous documents designed to assist communities with adopting, interpreting, and enforcing local regulations. Types of documents include: model regulations; booklets describing how to read different types of flood hazard maps; and technical manuals relating to different aspects of the regulations such as flood-proofing, elevation of structures, and special techniques for protecting mobile homes.

- **FIA Enforcement Activities.** To assure that communities are properly adopting and enforcing their local regulations, the FIA not only provides financial and technical assistance but also takes enforcement actions. Four enforcement mechanisms are currently available to the FIA:

1) COMMUNITY PROBATION: Communities that fail to keep their regulations up-to-date, do not adequately enforce the provisions of the regulations, or fail to meet certain other requirements may be placed on probation from the NFIP. A surcharge will be placed on all new and renewal flood insurance policies within a community on probation.

2) COMMUNITY SUSPENSION: Communities with more long-lasting or more serious records of noncompliance with required regulations may be suspended from the program. Flood insurance policies in suspended communities would not be eligible for renewal.

3) LAW SUITS: A third action available to the FIA is to sue a community to recover costs of paid-out insurance claims and to cause the community to take corrective actions. "FIA has filed a number of suits to collect monies paid out to insureds who have been damaged by the actions of local communities, states, or other property owners. The most notable of these was filed in May 1981 against two Louisiana communities, numerous developers and levee districts to collect $93 million in damages and requesting the court to direct the communities and levee districts to revise their floodplain management practices" (Scheibel, 1982).

4) SECTION 1316 DENIAL OF INSURANCE: The fourth enforcement mechanism available to the FIA is provided by Section 1316 of the National Flood Insurance Act of 1968. As amended, this section provides for the denial of flood insurance coverage for any property that the Federal Insurance Administrator finds has been declared by a duly constituted state or local authority to be in violation of state or local floodplain management regulations. Once a duly constituted state or local authority declares a structure to be in violation, the Administrator must deny flood insurance coverage provided that the individual or office making the declaration has the authority to do so and that the law or regulation violated was, in fact, intended to discourage or otherwise restrict land development or occupancy in the floodprone area. Section 1316 will only be implemented in instances where states or communities submit declarations specifically for that purpose.

FEMA reports that after three years of experience, community probation has proved to be an effective tool for stimulating community compliance. On the other hand, suits against communities have proven to be time consuming and expensive (MacKay, 1990).

Limitations of the NFIP

During a workshop on NFIP minimum standards in May 1988, participants agreed that the NFIP-required regulations "provide a basic, minimum level of floodplain management, but do not adequately address all situations, and that more stringent standards or more comprehensive approaches are warranted if the overall goals of sound floodplain management are to be achieved" (Association of State Floodplain Managers, Workshop #3, 1988).

The workshop participants noted that NFIP standards do not apply or are inadequate with respect to specifying minimum levels of protection for roadways (many flood-related deaths result from vehicles crossing flooded roads). Workshop participants also felt that the standards do not apply or are inadequate with respect to high risk erosion and mudslide hazard areas, alluvial fans, fluctuating lake levels, ice jams, moveable stream channels, and land subsidence, and with respect to future urbanization, floodplain encroachments, "B" and "C" zones, and protection of natural values.

Flooding due to inadequate storm drainage in areas outside the one percent annual chance floodplain (A and V zones) is of particular concern. Damages in C zones (outside the "500-year" floodplain) have accounted for about 30% of total payments on NFIP claims. Many of these flood losses are drainage-related. In addition, flood damages in areas outside the A and V zones accounted for some 27,250 repetitive loss claims between 1978 and 1987 (18% of total repetitive losses during that period) (Platt, 1989). As noted by the Association of State Floodplain Managers, "It makes little sense to insure structures flooded by stormwater, yet not require regulations" (Association of State Floodplain Managers, 1989).

Despite the recognition that NFIP standards do not adequately address all regulatory concerns, there was no support from the workshop participants for an overall strengthening or expansion of those standards. It was felt that because NFIP standards apply nationwide, such strengthening or expansion would not be appropriate to address needs of a regional nature. More stringent standards could also be counterproductive and cause a decrease in participation since some local governments feel the existing standards are already too restrictive. Strengthening the regulations to require one foot of freeboard above the base flood was the only suggestion that received some support. One state official did point out that because of state law, local governments in his state were prohibited from adopting standards more stringent than the NFIP standards (Association of State Floodplain Managers, Workshop #3, 1988).

Participants at another workshop where minimum standards for floodplain regulations were discussed reached similar conclusions and made additional suggestions. Many of these participants felt that states should adopt regulations that local communities would be responsible for implementing. This approach is seen to be working in several states, including Massachusetts and Wisconsin. A watershed approach for environmental and zoning regulations was viewed as important for addressing activities in or out of the floodplain that might increase the potential for flood damages or loss of floodplain natural resources.

It was suggested that the FIA could assist state and local governments in developing more comprehensive and stricter regulations in several ways. One recommended method was for the FIA to more strongly impress upon local communities that the FIA standards are only minimum standards and that each community should adopt more stringent regulations to meet their particular needs. To assist communities identify appropriate standards and regulations, it was suggested that the FIA compile a list of more restrictive standards and regulatory approaches, and make this information available to communities that wish to exceed FIA minimum standards.

Workshop participants expressed no general preference for the use of prescriptive standards versus performance standards, although performance standards were preferred for land-use oriented controls. It was noted that the use of performance standards requires more expertise at the local level. On the other hand, prescriptive standards (e.g., elevating to the minimum level required) are almost always implemented as required, even if a more stringent application might be appropriate in a particular situation (Association of State Floodplain Managers, Workshop #3, 1988).

Because uniform prescriptive standards sometimes result in social inequities and inefficient allocation of resources, it has been suggested that federal agencies should give greater attention to use of performance standards that can be implemented through local programs. Increased use of performance standards should not result in any greater hazard vulnerability than allowed under existing prescriptive standards (National Review Committee, 1989).

STATE AND LOCAL REGULATIONS

Since the 1960s, the number of state and local governments exercising regulatory authority over floodplain uses has increased markedly, and the variety of regulatory approaches has expanded greatly. A few communities had adopted local flood-related regulations as early as the 1940s, and by the mid-1960s several states had adopted some form of floodway regulatory program — channel encroachment laws, for example. Widespread adoption of state and local floodplain management regulations, however, did not occur until the 1970s. The increasing use of regulatory approaches can be attributed to several factors, including:

- Occurrence of serious or devastating floods in various parts of the country and recognition of the limitations of traditional structural measures in preventing flood damages.
- Requirements of the NFIP for adoption of community floodplain regulations.
- Increasing awareness and understanding of the applicability of alternative regulatory approaches.
- Increasing technical assistance by federal agencies to state and local governments in delineating hazard areas as a prerequisite to establishing regulations for use of such areas.

State floodplain management regulatory approaches include: direct state regulation of flood hazard areas; state standard-setting for local application; or flood hazard area regulation as part of broader resource protection and management programs.

To apply local floodplain regulations, a variety of approaches may be used, including: adoption of specific floodplain management or stormwater management ordinances; and incorporation of floodplain management provisions in zoning and subdivision regulations, housing and building codes, and resource protection regulations.

State Approaches for Floodplain Regulation

The following three approaches to floodplain management regulation are used by states and may be implemented with many variations.

1) DIRECT STATE REGULATION OF FLOOD HAZARD AREAS: This approach may focus on different parts of the floodplain. For example, direct state regulation may apply to selected floodways, floodplains and floodways throughout the state, floodways and inland floodplains, or to certain kinds of development in floodways or floodplains. State regulation of selected floodways may also be carried out with optional local regulation of other floodplains.

2) STATE STANDARD-SETTING FOR LOCAL REGULATION: This approach is similarly characterized by variation from state to state. Most states using this approach have prepared statewide rules and regulations (often with a model ordinance), and communities are required to meet certain minimum standards. In some states, adoption of local regulations is contingent upon provision of floodplain maps and technical data by the state, or is required only in communities identified by the state as subject to serious flooding.

3) DIRECT STATE REGULATION OR STANDARD-SETTING: This approach for floodplain management may also be accomplished through the incorporation of flood hazard provisions in broader resource protection and management programs. Examples include: state requirements for local planning and regulations with natural hazards protection as a requirement; state permitting requirements or state standards for local regulation of coastal or inland wetlands; and regulation of coastal hazard areas through coastal management statutes (U.S. Water Resources Council, 1971).

Local Approaches for Floodplain Regulation

Local regulation of floodplains generally occurs through the adoption of specific floodplain management ordinances or incorporation of flood-related provisions in existing regulations, for example:

1) ZONING REGULATIONS: Using various approaches, zoning regulations can include special standards for types of land uses permitted in floodable areas.

2) SUBDIVISION REGULATIONS: These regulations can incorporate provisions for improvements to alleviate potential flood hazards (e.g., drainage facilities, placement of utilities and streets); and avoiding encroachments onto floodable areas.

3) BUILDING CODES: Codes to control building design and construction materials can include specifications to reduce flood damages (e.g., elevation requirements, floodproofing, or designs to withstand flood velocities).

4) HOUSING CODES: Codes setting minimum standards for structure maintenance can include requirements for the repair of flood-damaged structures.

5) OTHER REGULATIONS: Other regulations that can incorporate flood-related provisions include sanitary and well codes, electrical codes, and plumbing codes that can establish standards for the location of infrastructure and utilities outside of flood hazard areas or floodproofing requirements for facilities and systems in flood hazard areas (U.S. Water Resources Council, 1971). Still other local regulations such as sand dune protection, wetlands protection, and farmland preservation regulations are usually focused on protecting some type of natural or cultural resource, and often have flood loss reduction benefits as well.

Status of State and Local Floodplain Management Regulations

Significant progress has been made in the past twenty years in state and local floodplain management regulatory efforts. Progress has been accomplished through: the adoption of state and local statutes and regulations, strengthening of existing statutes and regulatory programs, and incorporation of flood hazard provisions in a variety of related programs.

- **State Programs.** Prior to 1970, several states had adopted relatively limited flood encroachment laws and a few had adopted more comprehensive floodable areas regulations. Some examples of these early state efforts are:

  - Regulation of channel encroachments by several states, including New Jersey (1929), Washington (1935), and Connecticut (1955).

  - In 1936, the State of Washington broadened its 1935 channel encroachment law with a Flood Control Zone Act that authorized state identification and regulation of flood hazard zones.

  - In 1966, Wisconsin adopted a state statute requiring that all communities adopt floodplain zoning by January 1, 1968 (with the state authorized to adopt regulations if a community failed to do so), as well as a statute requiring shoreland zoning.

  - In 1967, Maryland adopted regulations for the "50-year" floodplain as part of its state water pollution control program.

  - In 1969, Minnesota adopted a floodplain management program, in conjunction with a shoreland zoning program, authorizing state standards for local regulation of floodplain areas contingent on the provision of technical flood data and maps from the State.

  By 1970, a total of 24 states had adopted statutes authorizing either direct state regulation of flood hazard areas or state standard-setting for local regulations. By 1980, seven additional states adopted new floodplain management regulatory programs (Kusler, 1982). Additional progress in state programs was also accomplished. For example:

  - State regulations often included more restrictive standards than required by the NFIP for delineation of floodway areas.

- At least 31 states had developed model ordinances and 18 had adopted procedural manuals to assist communities develop and implement their own floodplain management regulations.

- Many states also assisted communities with floodplain management regulations through workshops and training sessions and assistance for evaluating permit applications and proposed subdivision plats.

- Coordination of floodplain management with related land and water use planning and regulatory programs (such as coastal management, wetlands or critical areas programs) was becoming more important.

- Many state programs combined floodplain management regulation with nonregulatory floodplain management measures, including acquisition and relocation, public awareness, and hazard mitigation planning.

- At least eleven states have adopted some form of setback for new development along eroding coasts, in some cases extending beyond the inland reach of A-zones shown on FEMA maps.

Among the most recent regulatory setbacks adopted are those incorporated into the South Carolina Beachfront Management Act. The Act establishes a "no construction" zone beginning at the crest of the actual or theoretical dune line and extending landward 20 feet or 40 times the average annual erosion rate, whichever is greater. When the South Carolina legislature enacted the legislation, it anticipated that the Act would result in the gradual elimination of structures built too close to the ocean and subject to severe damage or destruction during hurricanes and other coastal storms. The legislature also apparently anticipated that the state would have to compensate some property owners for their inability to build or to rebuild damaged structures.

In September 1989, South Carolina was hit by Hurricane Hugo, the most destructive hurricane ever to strike the U.S. mainland. The South Carolina Coastal Council determined that 159 oceanfront homes were at least two-thirds destroyed by the storm and cannot be rebuilt as they were. As one official commented "When the General Assembly passed this law it knew there would be occasions when the state would have to compensate property owners ... But instead of a gradual retreat from the shore that many legislators had expected, we were hit by a big storm and now face a big payment up front ... We'll see how serious the state really is about enforcing the law when the General Assembly returns in January" (ENR, 11,89).

Following Hurricane Hugo, FEMA noted that the Beachfront Management Act "didn't play a big role" in minimizing damage from Hugo, but that "In the future it will be increasingly important." The "Interagency Hazard Mitigation Team Report" prepared following Hurricane Hugo stated that it is "crucial that the concept of a gradual, strategic retreat from the ocean remain a part of coastal management" at the state and local levels (ENR, 7,89).

In June 1990, several amendments to the Beachfront Management Act were passed. Changes included elimination of the no construction zone; the methodology for determining the baseline was changed from the theoretical dune to the location of

> the primary frontal dune; a special permit provision was established to allow construction seaward of the dune baseline; the 40-year setback line can be adjusted to take into consideration beach renourishment projects; and restrictions on replacement of damaged seawalls were to become increasingly stringent over time. As a result of these changes, most of the homes that would have been prohibited from being rebuilt under the original law can now be rebuilt.

Some of the major problems hindering the effectiveness of state floodplain regulatory programs in the early 1980s were: lack of specific expertise; inadequate funding and staffing; inadequate statutory authority (e.g., applicability to limited portions of floodplains or broad allowance for exemptions); lack of flood maps sufficiently detailed for regulatory purposes; conflicts between state and federal policies (e.g., federal policies less stringent than state standards); fragmentation of regulatory authority; and inability to deal with existing floodplain development (Kusler, 1982).

By 1988, every state had enacted enabling legislation authorizing state and local floodplain regulations that meet the minimum standards established by the NFIP. Missouri was the last state to authorize all local governments to adopt floodplain regulations. Due to the need to permit all residents to obtain flood insurance, the Missouri Legislature in 1980 and 1983 granted county commissions the authority to regulate floodplains. Some counties, however, require a general referendum to participate (Association of State Floodplain Managers, 1988).

A recent report (Burby, 1985) reported on the results of surveys taken in 1979 and 1983 on the status of floodplain management at the state and local levels. Some of the findings related to regulatory components of <u>state</u> floodplain land-use management programs are as follows:

- The state role in flood hazard management is primarily one of informing, aiding and coordinating local flood management efforts.

- State agency officials ranked regulation fourth among the program areas in which they thought states should be involved. This may be due to the fact that the state regulatory role related to nonstructural flood hazard management is relatively new, compared to active regulation related to structural flood protection.

- State regulatory efforts included efforts related to structural flood protection (e.g., permits for flood control works); nonstructural flood protection; and flood-related environmental protection regulations (see Table 11-2). "None of the five nonstructural program components listed [in Table 11-2] are used by more than half of the states. Fifty percent do monitor compliance with local flood management plans and nearly a third of the states (32 percent) require permits for buildings in the floodplain and/or set standards for local regulation of flood hazard areas."

- Much of the state technical assistance role is aimed at enhancing the local capacity to develop and implement local level nonstructural measures and regulations. However, while the majority of local governments received assistance related to the NFIP from state sources, relatively few communities reported receiving other types of assistance from the state (e.g., one out of six had received help with disaster preparedness planning and fewer had help in administering local floodplain regulations or used state hydrologic data services). Communities most likely to seek state assistance were those with the most severe flood hazards.

Table 11-2. State Regulatory Program Components in Place, 1983.

PROGRAM COMPONENT	PERCENT OF STATES	MEAN STAFF SIZE
STRUCTURAL FLOOD PROTECTION:		
1. State permits for flood control works and/or obstructions of navigable waters	90	6.5
2. Dam safety inspections	86	5.4
NONSTRUCTURAL FLOOD PROTECTION:		
1. State monitoring of compliance with flood management regulations	50	8.2
2. State permits for buildings and other structures located in either the floodway for the floodway fringe	32	13.2
3. State standards for local regulation of flood hazard areas	32	7.9
4. State requirements for local regulation of flood hazard areas with provision for state regulation if localities fail to act	16	8.2
5. State mandate of participation in National Flood Insurance Program	8	3.2
FLOOD-RELATED ENVIRONMENTAL PROTECTION:		
1. Wetlands protection/dredge and fill regulations	56	9.0
2. Sedimentation pollution control/stormwater management regulations	54	8.5
3. Coastal management requirements and hazard mitigation regulations	44	10.8

Source: Burby, Taymond J. and Steven P. French. Flood Plain Land Use Management: A National Assessment. Studies in Water Policy and Management, No. 5. Boulder, Colorado: Westview Press, 1985.

- **Local Programs.** Several early studies indicated that very few communities had adopted local floodplain management regulations prior to 1970. A 1957 study identified only 35 local regulatory programs, most of which were considered ineffective by the author. A 1968-69 study identified 183 municipalities and 71 counties with floodplain zoning, and 167 municipalities and 27 counties with flood-related subdivision regulations. Most of these were located in the Tennessee Valley area and in Iowa, Wisconsin and Minnesota.[5]

  After 1970, thousands of communities adopted local floodplain management regulations as a result of their participation in the NFIP. Community enrollment in the NFIP began slowly, then increased rapidly with the adoption of stronger incentives in the 1973 Flood Disaster Protection Act. In 1970, only about 300 to 400 communities had adopted floodplain regulations. After the 1973 Flood Disaster Protection Act provided for withholding of federal disaster assistance and other federal benefits for construction activities in the floodplain to communities not participating in the NFIP, thousands of communities joined the program and adopted local floodplain manage-

[5] The studies referred to are cited in *Regulation of Flood Hazard Areas, Vol. 3*, prepared for the U.S. Water Resources Council by Jon A. Kusler, 1982, page 113.

ment regulations. From 1974 to 1977, 13,000 communities enrolled in the NFIP, and by May 1981, community enrollment increased to over 17,000. As of September 7, 1988, 15,716 communities were participating in the regular phase of the NFIP, and another 2,081 were participating in the emergency phase of the program (Matticks, 1988).

In adopting the mandatory floodplain management regulations, most local governments adopted the minimum NFIP standards, although a limited number adopted standards exceeding the NFIP requirements (sometimes to comply with more restrictive state standards or to reflect local conditions and attitudes). In addition, several thousand communities had adopted regulations through related programs that incorporated flood hazard management or flood loss reduction as an objective. These included regulations for wetland protection, shoreland zoning, coastal zone management, and preservation of prime agricultural land. Also, like many of the states, communities have increasingly combined their regulatory efforts with nonregulatory floodplain management measures in the 1970s (Kusler, 1982).

Local governments surveyed by Burby (1985) in 1979 and 1983 were selected from those participating in the emergency or regular phase of the NFIP. Some of the findings related to regulatory components of <u>local</u> floodplain land-use management programs are as follows:

1) USE OF FLOODPLAIN MANAGEMENT REGULATIONS:

- Regulations are the most commonly used method of achieving community floodplain goals.

- Three types of regulations — subdivision ordinances, zoning, and elevation requirements — have been adopted by a majority of riverine and coastal communities participating in the regular and emergency phases of the NFIP. Other types of related regulations (e.g., sedimentation and erosion control regulations) were less common.

- The NFIP has a strong effect on the types of management measures used. Communities in the regular phase were more likely to use specific elevation, floodproofing, and floodway regulations in their land-use management programs.

- Local conditions are important in determining the contribution of regulations to a community's floodplain management effort. "For example, traditional land-use management measures, such as floodplain zoning and floodway encroachment regulations, may not be very effective when a community's floodplains have high locational advantages or when there is a scarcity of developable land outside of flood-hazard areas. In those instances, land-use management might more appropriately stress public acquisition rather than regulation (or levees might be more appropriate)."

2) USE OF NONREGULATORY MEASURES IN COMBINATION WITH REGULATIONS:

- Local governments were much less likely to use nonregulatory approaches than they were to have enacted regulations. (For example, about one in five of the communities surveyed in 1979 and one in ten of those in the 1983 survey avoided floodplain locations when siting public facilities. While many localities had acquired floodplain land for recreation and open space use, incentives such as preferential taxation or density exchanges were not widely used, and only about one-third of the communities used public education to discourage floodplain development.

- "In general, communities tend to use a wider array of land-use management measures when they have had extensive previous experience in using land-use management to deal with community problems, when they assign some priority to solving floodplain problems, and when they have more resources to mount a vigorous management program."

3) EXISTING VS. FUTURE DEVELOPMENT:

- Regulatory approaches were generally not effective in controlling flood losses to existing development. "Most floodplain land-use management measures are designed to prevent increases in damage potential by affecting the design (and location) of new development. With the exception of relocation measures and measures regulating the improvement of existing structures, they are not designed to reduce potential damage to existing development."

4) PROGRAM SCOPE AND FOCUS:

- There is wide variation in the scope and focus of local floodplain management programs, including variation in the types of regulatory measures used. "Less than a quarter of the communities surveyed in 1979 had programs that comprehended subdivision or zoning regulations, elevation requirements or floodway regulations, and land acquisition or relocation. Thirty-seven percent had gone as far as enacting elevation or floodway regulations... while one-fifth had adopted programs that were limited to the use of traditional subdivision or zoning regulations ... and a fifth had not adopted zoning, subdivision, elevation, or floodway regulations, but were relying on their building codes to reduce future flood losses... Communities surveyed in 1983, which, on average, were smaller than those surveyed in 1979, were using fewer action instruments in their floodplain land use management programs, but the measures they were employing tended to be as focused, or more so than those used by communities in the 1979 survey."

- A number of factors contribute to the variation in program scope and focus — the proportion of the community at risk, extent of floodplain development, community perception of risk, and other objective factors, such as size of community and available fiscal resources, extent of urbanization, availability of developable sites outside the floodplain, etc.

5) RIVERINE VS. COASTAL COMMUNITIES:

- Differences in the scope of floodplain management programs between riverine and coastal communities in the regular phase of the NFIP were not significant. But, "reflecting the heightened perception of flood hazards in coastal areas ... coastal communities participating in the NFIP emergency phase were more likely to have broader programs than riverine communities in the emergency phase." In addition, "one reason for coastal communities' continued interest in land use management as a hazard mitigation adjustment ... is that structural solutions are not as viable an alternative as they are for riverine communities."

- There were differences in the kinds of regulations adopted by riverine and coastal communities. "Coastal communities in both the emergency and regular phases of the National Flood Insurance Program, for example, were more likely than riverine communities to require that new construction be elevated above the base ("100-year") flood level. Coastal communities were also somewhat more likely to have adopted regulations to protect wetlands and other types of critical areas, and, of course, to have adopted regulations to protect sand dunes."

Regulations Exceeding NFIP Minimum Requirements

The National Flood Insurance Program established minimum levels of floodplain management regulations that participating communities must adopt based on the level of information made available to the community by the FIA. Many states and communities have determined that these minimum regulations, while providing a good level of protection, are insufficient to meet all their needs. In response, some states and many communities have adopted their own regulatory requirements that in some manner exceed the minimum requirements of the NFIP. There are a number of ways in which states and communities have exceeded NFIP minimum standards. *Information on state actions presented here and in subsequent sections of the Assessment Report, and shown in a number of tables in this part of the report, is derived primarily from a survey taken by the Association of State Floodplain Managers in 1987 and 1988, specifically for the Assessment Report* (Association of State Floodplain Managers, 1988). Each of the 50 states, the District of Columbia, Guam, Puerto Rico, and the Virgin Islands received a survey form. All 50 states and the District of Columbia completed the forms. Information on actions taken by local governments is taken from numerous sources.

The number of communities with some form of stricter regulatory requirements is unknown, but clearly the number is in the thousands, since many states impose requirements beyond NFIP minimums on each unit of local government. Even without state requirements, probably thousands of communities have adopted at least one regulatory requirement that exceeds NFIP minimums. The large number of these communities is indicated by a partial listing of communities with requirements exceeding NFIP minimums prepared by FEMA's regional office in Atlanta, Georgia. The regional office identified 236 communities and counties in eight states that had passed ordinances or other local legislative acts to establish a standard beyond NFIP minimums (Woodard, 1987).

- **Regulation of Riverine Areas.** As shown in Table 11-3, 27 states have established regulations that require local governments to meet one or more standards that are more stringent than standards required by the NFIP. Eighteen states have opted to directly regulate all or portions of the floodplain instead of relying on or mandating local regulations.

  California, Minnesota, Montana, New Jersey, and New York have statutes allowing the state or another flood control agency to directly regulate if the local government does not adopt or enforce the mandated ordinance. Colorado and Kansas have provisions that allow the governor or attorney general to order abatement of a violation of a local ordinance should a community or county fail to do so. Two states, Arkansas and Nebraska, have recently repealed provisions for state takeover of local regulations. Conversely, three states — Alabama, Illinois, and Iowa — have provisions to allow local governments to assume the state permitting program if certain requirements are met.

Table 11-3. State Regulatory Standards that Exceed Minimum NFIP Requirements for Riverine Floodplains.

	FLOODWAY STANDARDS	FLOODWAY RISE	FRINGE STANDARDS	BUILDING STANDARDS
Alabama				
Alaska				
Arizona	L,P,R		L,R	F: 1Ft.,L,P,R
Arkansas				
California	AS,L+		L+	
Colorado				
Connecticut				
Delaware				
District of Columbia	S		S	F: 1.5Ft.
Florida	S,L			R
Georgia	L			
Hawaii				
Idaho				
Illinois	S,AL	.1Ft.		AP
Indiana	S,L	.1Ft.	L	F: 2Ft.,R
Iowa	S,L	D	S,L	F: 1Ft.,P
Kansas	L+		L+	
Kentucky	S		S	
Louisiana				
Maine	AS,L			F: 1Ft.+
Maryland	S	D	S	F: 1Ft.
Massachusetts	S,L	0Ft.	S,L	
Michigan	S	D	S	F: 1Ft.,P
Minnesota	L+	D:.5Ft.	L+	R
Mississippi				
Missouri				
Montana	L+	.5Ft.	L+	F: 2Ft.,P,R
Nebraska	AS		AS	F: 1Ft.
Nevada				
New Hampshire	AS			
New Jersey	S	.2Ft.	L+	P
New Mexico				
New York	L+		L+	
North Carolina				
North Dakota				
Ohio				
Oklahoma				
Oregon	L		L	
Pennsylvania	S,L		L	AF: 1.5Ft.
Rhode Island	S		S	
South Carolina				
South Dakota				
Tennessee				
Texas				
Utah	S,P			S,L+
Vermont				
Virginia				L
Washington	L		L	P
West Virginia				
Wisconsin	L	.01Ft.	L	F: 2Ft.,P,R
Wyoming				

NOTE: This table only identifies state standards or procedures that exceed minimum NFIP floodplain regulatory standards
A = Rules apply only in certain areas, e.g., California directly regulates floodways only in the Central Valley
D = Allowable floodway rise depends upon impact to existing development
F = Freeboard
L = Local regulations must meet state requirements
P = Buildings or residences prohibited from floodway
R = Reconstruction of buildings more stringent than NFIP rules
S = State directly regulates development
\+ = State or other agency may directly regulate or enforce if locals do not

Source: Association of State Floodplain Managers. "State Floodplain Management Programs. Results of a Survey Conducted by the Association of State Floodplain Managers for L.R. Johnston Associates," 1988.

Twenty-six states have floodway regulatory standards more restrictive than required by the NFIP. These states are more likely to directly regulate some or all of the floodways rather than the flood fringes. This is due to the technical nature of floodway regulations and to the fact that the impacts of floodway development extend beyond corporate limits. For example, New Hampshire's Water Resources Board has strict requirements for channel work and other activities that affect flowage. In 1987 the State of Washington enacted legislation prohibiting new residences in the floodway and giving the State's Department of Ecology authority to set additional requirements and to review and approve local ordinances.

Ten states have an allowable rise standard more restrictive than the federal standard of one foot. Indiana requires all floodway maps to be based on a 1/10th foot rise. Iowa, Maryland, Michigan and Minnesota restrict the allowable rise to less than one foot if the rise would affect existing development.

Eighteen states and hundreds of communities have building construction requirements stricter than the NFIP's. The most common additional standard is the standard for "freeboard" which requires new buildings to be elevated higher than the base flood level. Freeboard may be applied to all buildings or only certain types. Pennsylvania state law requires new jails, hospitals, nursing homes, mobile home parks, and hazardous materials facilities to be 1.5 feet higher than the base flood level. Arizona requires that all new and replacement mobile homes have the lowest structural member elevated 1.0 foot above the "100-year" flood elevation.

Other building construction standards include prohibition of new buildings or new residences in the floodplain or floodway. For example, Montana and Wisconsin do not allow any new buildings in the floodway. Indiana, Michigan and Washington prohibit new residences in designated floodways.

A few states have substantial improvement regulations that differ from the NFIP 50% standard. Indiana uses 40% and Montana treats a building damaged over 50% as a new building and does not allow reconstruction in the floodway. Michigan requires that floodplains in new subdivisions must be identified and that minimum building areas must be provided above the flood elevation (Association of State Floodplain Managers, 1988).

Subdivision regulations in Arizona set aside floodprone land from development. A density transfer plan worked out with developers encouraged the preservation of open space by allowing units permitted under normal density requirements to be transferred from the hazard portion of a tract of land to the nonhazard portion. This approach has resulted in very effective land use and design changes, with dwellings on the fringes of lakes and lagoons with common acreage maintained as open space (Federal Emergency Management Agency, 1987).

- **Regulation of Coastal and Lakeshore Floodplains.** As shown in Table 11-4, most coastal states have enacted some regulations to control shoreline development, usually under the state's coastal zone management program. Direct state permitting is more common with respect to coastal floodplains than riverine floodplains.

  Except for Ohio, all of the Great Lakes states have established lakeshore regulatory standards or permit programs. Ohio is currently seeking passage of coastal zone management legislation. These standards or programs are usually administered as part of a shoreland management program, most of which were created before the Federal Coastal Zone Management Program. Fourteen states have regulations to preserve or protect sand dunes, and twelve states regulate areas subject to rapid erosion (Association of State Floodplain Managers, 1988).

- **Regulation of Special Hazards.** Special hazards accompany flooding and cause greater damage than the usual forces of flowing water. As shown in Table 11-5, most states have not yet addressed these hazards, with the exception of hazardous materials. Those that have prefer direct state regulation over mandating local regulations.

  The Colorado State Geological Survey has developed nonmandatory guidelines for development in areas of geologic hazards. With funding assistance from FEMA, Colorado has also developed a landslide mitigation plan that may serve as a model for other states.

  Twelve states have special rules for areas below dams or protected by levees. Two states have special regulations covering alluvial fans and two states address mudflow areas.

  At least 15 states have special rules to protect public health in floodplains. Montana requires that septic tank drain fields be located at least 100 feet from the "100-year" floodplain, while New Hampshire and Alabama prohibit these fields in the "50-year" floodplain. Even more states restrict hazardous materials (Association of State Floodplain Managers, 1988).

  During a 1988 workshop that addressed state and local regulations with broader coverage or more stringent requirements than required by the NFIP, participants agreed that more stringent actions were necessary. These participants noted, however, that there was little documented data available to demonstrate the effectiveness of such measures (Association of State Floodplain Managers, Workshop #8, 1988).

Assistance to Local Regulatory Programs

Implementation and enforcement of local floodplain regulations may not be effective without federal and state planning and technical assistance to local governments.

Two common forms of assistance are preparation of a model ordinance, and help in modifying a model ordinance to meet local needs. While FEMA has produced model ordinances, state versions that are tied to the state's unique statutory authority, political structure, and flooding conditions are much more useful. One drawback of model ordinances is that communities often adopt them verbatim without taking the time to understand their requirements.

Table 11-4. State Regulations for Coastal and Lakeshore Floodplains.

	COAST	LAKESHORE	SAND DUNES	EROSION
Alabama	S		S	
Alaska				
Arizona				
Arkansas				
California	S		S	
Colorado				
Connecticut	S,L		S,L	
Delaware	S,L		S	S
District of Columbia				
Florida	L		S,L	S,AL
Georgia	S		S	L
Hawaii	S			
Idaho				
Illinois		AS		
Indiana		S		
Iowa		S		
Kansas				
Kentucky		S		
Louisiana	A	L		
Maine	AS,L	S,L	AS,L	S
Maryland	S			S
Massachusetts	SL	SL	L	
Michigan		AS	S	L+
Minnesota		L		
Mississippi	S			
Missouri				
Montana				
Nebraska				
Nevada				
New Hampshire	L	S		
New Jersey	S		S	
New Mexico				
New York	L+	L+	L+	L+
North Carolina	S,L		S,L	S,L
North Dakota				
Ohio				
Oklahoma				
Oregon	L	L	L	L
Pennsylvania	L			
Rhode Island	S		S	
South Carolina	S			
South Dakota		S		L
Tennessee				
Texas	AS			
Utah		L/S		S
Vermont				
Virginia	S			
Washington	L	L		L
West Virginia				
Wisconsin		L		
Wyoming				

A = Rules apply only in certain areas, e.g., Illinois and Michigan lakeshore regulations apply only to the Great Lakes
L = Local regulations must meet state requirements
S = State directly regulates development
+ = State will directly regulate if locals do not

Source: Association of State Floodplain Managers. "State Floodplain Management Programs. Results of a Survey Conducted by the Association of State Floodplain Managers for L.R. Johnston Associates," 1988.

Table 11-5. State Regulations for Special Hazard Areas.

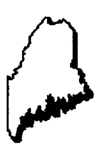
	AREAS BELOW DAMS	AREAS BEHIND LEVEES	ALLUVIAL FANS	MUD FLOODS	PUBLIC HEALTH STANDARDS	HAZARDOUS MATERIALS STANDARDS
Alabama						
Alaska						
Arizona			L		X	X
Arkansas						
California	S				X	X
Colorado		S				
Connecticut						
Delaware						
District of Columbia						X
Florida	S	S			L	L
Georgia						
Hawaii					X	X
Idaho						
Illinois					X	
Indiana						
Iowa	S	S				X
Kansas						X
Kentucky						
Louisiana						
Maine					X	X
Maryland	S				X	X
Massachusetts						
Michigan		S			X	X
Minnesota	SL	L				
Mississippi						
Missouri						
Montana					X	X
Nebraska	AS	AS				
Nevada						X
New Hampshire					X	
New Jersey					X	X
New Mexico						
New York					X	
North Carolina						
North Dakota						
Ohio						
Oklahoma					X	
Oregon	L	L	L	L		
Pennsylvania					X	X
Rhode Island						
South Carolina	S					
South Dakota						
Tennessee					X	
Texas						X
Utah	S	S		S		X
Vermont						
Virginia						
Washington						
West Virginia						
Wisconsin	L	L				X
Wyoming						

A = Rules apply only in certain areas
L = Local regulations must meet state requirements
S = State directly regulates development
X = State has regulatory standards for this special hazard
+ = State will directly regulate if locals do not

Source: Association of State Floodplain Managers. "State Floodplain Management Programs. Results of a Survey Conducted by the Association of State Floodplain Managers for L.R. Johnston Associates," 1988.

To avoid having communities adopt inappropriate provisions of a model ordinance, the State of Tennessee prefers to separately design each local ordinance to ensure that floodplain rules are integrated with other local land-use controls.

Helping communities understand their ordinances is another important type of state assistance. All but seven states reported that they respond to calls for this type of help. As shown in Table 11-6, 37 states conduct training programs, and 26 have published handbooks on how to administer floodplain regulations. Most states also monitor local performance and help local officials respond to violations. While these activities, particularly assessment services, are funded by FEMA's Community Assistance Program (CAP), many of these same services are also provided by states not participating in the CAP. Maine and Minnesota have published standard building permits, as-built certifications, and similar forms for local officials to use.



In 1983, the Maine legislature enacted "Rule 80K" to allow code enforcement officials to take code violations to court. Once an official is trained, he/she can take a land-use violation directly to the district court without an attorney. Procedures are followed that are less formal but do not sacrifice the defendant's due process rights. The court can both levy a fine and order abatement of the violation. The result of Rule 80K is cheaper and faster enforcement.

Faced with a large number of rural communities needing professional staff support, Vermont places priority on direct assistance. State staff will even make site inspections and set building elevations for the local officials.

In addition to a model ordinance, the State of Texas published ***The State of Texas Floodplain Administrator's Manual*** and distributes a quarterly newsletter for local officials. The State has presented regional seminars for local administrators, two-day legal seminars, and a series of seminars focused on realtors and builders. The State conducts Community Assistance Visits and maintains a Community Status Report and a master list of local administrators on computer.

States also assist local officials by facilitating communication among them. Kentucky, Montana, and Texas publish directories of local administrators. Arizona, California, Illinois, Louisiana, and Michigan have helped create and support state associations of local floodplain managers (Association of State Floodplain Managers, 1988).

Table 11-6. State Assistance to Local Regulatory Programs.

	MODEL ORDINANCE	HELP ADOPT	TRAIN	ADMIN. HANDBOOK	HELP ADMIN.	MONITOR ADMIN.	HELP WITH VIOLATIONS
Alabama	X	X	X		X	X	X
Alaska	X	X	X	X	X	X	X
Arizona	X	X	X	X	X	X	X
Arkansas	X	X	X		X	X	X
California	X	X	X	X	X	X	X
Colorado	X	X	X	X	X	X	X
Connecticut	X	X	X	X	X	X	X
Delaware		X					
District of Columbia	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Florida	X	X			X	X	X
Georgia		X	X		X	X	X
Hawaii							
Idaho	X	X	X		X	X	X
Illinois	X	X	X	X	X	X	X
Indiana	X	X	X			X	X
Iowa	X	X	X		X	X	X
Kansas	X	X	X		X		X
Kentucky	X	X	X	X	X	X	X
Louisiana	X	X		X	X	X	X
Maine	X	X	X		X	X	X
Maryland	X	X	X		X	X	X
Massachusetts	X	X	X		X	X	
Michigan	X	X	X	X	X	X	X
Minnesota	X	X	X	X	X	X	X
Mississippi	X	X			X		X
Missouri	X	X	X	X	X	X	X
Montana	X	X	X	X	X	X	X
Nebraska	X	X	X	X	X	X	X
Nevada	X	X		X			
New Hampshire	X	X	X	X	X		
New Jersey	X				X	X	X
New Mexico	X						
New York	X	X	X	X	X	X	X
North Carolina	X	X	X	X	X	X	X
North Dakota	X	X	X		X	X	X
Ohio	X	X	X	X	X	X	X
Oklahoma	X	X	X	X	X	X	X
Oregon	X	X	X		X	X	X
Pennsylvania	X	X	X	X	X	X	X
Rhode Island				X	X	X	
South Carolina		X	X	X	X	X	X
South Dakota			X		X		X
Tennessee		X	X		X	X	
Texas	X	X	X	X	X	X	
Utah	X	X	X	X		X	
Vermont	X	X			X	X	X
Virginia				X	X	X	
Washington		X	X		X	X	X
West Virginia						X	
Wisconsin	X	X	X	X	X	X	X
Wyoming					X		

Source: Association of State Floodplain Managers. "State Floodplain Management Programs. Results of a Survey Conducted by the Association of State Floodplain Managers for L.R. Johnston Associates," 1988.

Exemptions from Local Regulatory Authority

Two common exceptions to local floodplain regulatory authority exist. First, most local governments do not have the authority to regulate federal or state property or development by other local governments. Federal and state development activities are often governed by executive orders or statutes. All states now control their own development activities. A notable exception to exemption of federal activities from state and local regulation is provided by the coastal consistency requirement of the Coastal Zone Management Act (CZMA). The CZMA requires all federal activities, including such actions as construction of structural flood control measures, to be consistent, to the maximum extent possible, with the approved state coastal management program.

Second, many statutory authorities have exempted certain types of activities from regulation. Typically, these are activities, such as agricultural and transportation activities, that are important to the state's economy. For example, because Arizona has a significant copper industry, the Arizona legislature has exempted mining from floodplain regulations (Association of State Floodplain Managers, 1988). Structures listed on the National Register of Historic Places or on a state list of historic sites are also exempt from requirements of the NFIP.

PRIVATE ROLE IN FLOODPLAIN REGULATION

The private sector has only an indirect role in floodplain regulation, principally through the development of model building codes. Most states and communities have adopted (with amendments) one of three model building codes that apply to large regions of the country. The Standard Code, published by Southern Building Code Congress International, Inc. is most commonly used in the South. The BOCA code, published by Building Officials and Code Administrators International, Inc., is used in the East and Midwest. The Uniform Code, published by the International Congress of Building Officials, is used throughout the West.

During the early years of the NFIP, elevation, floodproofing, and other construction-related provisions of the NFIP minimum regulations were not incorporated into the model building codes (Manning, 1989). This early deficiency has since been resolved, and each of the model codes has been extensively revised over the years to reflect new developments in construction techniques and materials and in government regulations, including much of the information related to floodproofing and elevation of structures (Federal Emergency Management Agency, 1986). Although standards for construction in flood hazard areas have now been incorporated into the regional building codes that are in widespread use throughout the country, not all states and localities have adopted one of these codes or an equivalent code of their own.

Following Hurricane Hugo, the "Interagency Hazard Mitigation Team Report" noted "that South Carolina has no statewide building code and that only about half of the cities and towns and one-third of the counties in the state have adopted the Standard Building Code. The report stated that "The state should mandate the adoption of the Standard Building Code by all local jurisdictions." (ENR, 12,89).

Posthurricane inspections of damaged structures revealed that most of the structures destroyed or severely damaged by Hurricane Hugo in South Carolina were either constructed prior to existing floodplain regulations or were not constructed to meet current building codes. The most common causes of failure were wind damage and foundation failure due to erosion scour. Buildings that were constructed to current codes (particularly with regard to adequate depth of pilings) sustained relatively little damage. (Rogers, 1989).

EFFECTIVENESS OF REGULATIONS

Little hard data exists, at national, state or local levels, to support an evaluation of the effectiveness of floodplain regulations in reducing flood losses. The comment of one local official typifies a situation that exists across the Nation: "Pima County [Arizona] has collected and analyzed no data which [can be used to] measure the success of floodplain regulations in reducing flood losses" (Fuller, 1989).

Despite the lack of supporting data, floodplain regulations are widely — but not universally — viewed as an effective floodplain management tool for limiting the vulnerability of new development to flooding. The fact that over 18,000 communities now participate in the NFIP has ensured a much greater level of recognition of flood problems, as well as recognition that land-use decisions can affect flooding and flood damages (National Review Committee, 1989). The regulatory aspects of the NFIP are considered to have significantly moderated floodplain development and, therefore, damage that would have occurred without the program (Corps of Engineers, 1989).

Not everyone agrees that floodplain regulations are effective. Perceived ineffectiveness of local regulatory programs is attributed, in part, to lack of personnel and funding. Just as important, however, is the lack of political support for floodplain management — it is simply not a priority for most local governments. Research has indicated that local regulatory programs are more effective in states with strong land-use planning programs and policies (Smith, 1989).

Debate over the effectiveness of floodplain regulations is often linked with the availability of flood insurance through the NFIP. Many have argued that the availability of flood insurance has actually increased development in floodplains beyond the level that would have occurred without insurance availability. While there can be no doubt that development in floodplains has greatly increased since the NFIP was established, there is not solid evidence to indicate whether or not the availability of flood insurance has induced development. There is, however, extensive anecdotal evidence indicating that the strong desire to live or vacation in coastal communities is primarily due to the numerous natural and cultural amenities found in beachfront areas (McShane, 1988). Furthermore, development on many units of the Coastal Barrier Resources System continues although it was initially believed that the unavailability of flood insurance and federal financial assistance would limit or discourage much of this development (McShane, 1990).

There is data to indicate that the development occurring after floodplain regulations are adopted is less prone to flood damage than development occurring before adoption of the regulations. A recent analysis of flood insurance claims data by FEMA for the period 1978 through 1989 shows losses experienced by pre-FIRM structures (in regular and emergency program communities) at 21.7 per 1,000 policies as compared to only 5.7 per 1,000 for post-FIRM structures (in regular program communities). In other words, construction started prior to publication of the FIRM and the community's adoption of detailed floodplain management ordinances are 3.8 times more likely to be flood-damaged than post-FIRM buildings (Thomas, 1990).

The combination of regulatory efforts and urban growth have resulted in and will continue to encourage dense development adjacent to regulatory boundaries, and such concentrations of development may increase vulnerability to catastrophic losses from large floods (National Review Committee, 1989). This increased vulnerability resulting from regulations may be viewed as analogous to the vulnerability faced by areas protected by structural measures when a flood greater than the design flood is experienced.

Improved Enforcement

Provisions of floodplain regulations can be strengthened, they can be applied to more types of flooding situations, and other regulatory improvements can be made, but the most important opportunity for improvement appears to be increased enforcement. The need for improved enforcement of floodplain regulations that are often unpopular with many property owners has been expressed by practically all groups concerned with floodplain management. To achieve improved enforcement, many concerned groups and individuals note that:

1) Federal-level standards are important to impose regulations on those communities not particularly interested and supportive of those communities and states who wish to impose more stringent standards. These federal standards must include effective enforcement provisions.

2) A strong state program and support is necessary that must also include enforcement provisions.

3) Regulations must balance loss reduction with maintenance of the natural and beneficial uses of the floodplain, and federal regulations need to explicitly embrace these concepts.

4) Continuous programs of information and education for local officials are necessary.

5) Available sanctions for noncompliance must be aggressively pursued.

6) Communities must have flexibility to address their special flood hazard problems without relaxing minimum requirements.

Strengthening the balance between loss reduction and protection of floodplain natural resources has special significance. Currently, floodplain regulations are designed specifically to reduce loss of life and property. They provide incidental protection to sand dunes and mangroves because these natural features are known to absorb wave impacts in coastal areas. Otherwise, regulations do nothing to protect floodplain natural and cultural resources, and may actually contribute to resource destruction. To the extent that floodplain regulations (and other floodplain management tools as well) allow new development in floodplains, they contribute to loss of floodplain natural resources and associated value. Lives and property may not be at serious risk, but natural resources are frequently sacrificed to make room for the new development.

DEVELOPMENT AND REDEVELOPMENT POLICIES

In addition to the use of regulatory methods to control development in floodplains, federal, state and local governments may establish programs, policies, and directives that seek to avoid inappropriate use of the floodplain. Typically, these types of policies require government agencies to take action themselves rather than impose a requirement on the private property owner.

DESIGN AND LOCATION OF SERVICES AND UTILITIES

The design and location of services and utilities can have both direct and indirect impacts on flood losses. If roads, bridges, sewer lines, and other utilities are constructed in floodprone areas without adequately taking into account the flood hazard, these utilities may be vulnerable to flood damages. In addition to directly suffering flood losses, services and utilities located in and through floodprone areas can indirectly lead to more intensive use of the floodplain. For example, placement of a sanitary sewer line in a floodplain may create additional pressure on local authorities to allow development on the floodplain and connection to the sewer line.

Federal Policies

Federal legislation and regulations often include policies relating to the location of services and utilities in floodprone areas. There are several policies with particularly significant impact.

- **National Environmental Policy Act.** The National Environmental Policy Act (NEPA) of 1969 for the first time established a requirement that federal agencies consider the environmental impacts of proposed activities. The requirement for preparation of an environmental assessment or environmental impact statement has been of major importance in identifying federal activities that may be subject to flood damage and that may cause damage to floodplain natural resources. The opportunity for public review and comment on draft impact statements has been viewed as one of the strongest aspects of NEPA.

- **Executive Order 11988, Floodplain Management.** Executive Order 11988, Floodplain Management, was issued by the President in 1977 to bring together federal policies to protect against both flood hazards and the degradation of floodplain natural resources. The Order was issued in response to recommendations in both the National Flood Insurance Act and NEPA. E.O. 11988 superseded and expanded a 1966 executive order, Flood Hazard Evaluation (E.O. 11296), which had directed federal agencies to take a leadership role in guiding floodplain use and in avoiding uneconomical, unnecessary, and hazardous use of floodplains. A 1975 General Accounting Office (GAO) report found that "Executive Order 11296 proved to have a limited effect in reducing flood losses due to the lack of agency implementing procedures and limited compliance by Federal agencies" (Federal Emergency Management Agency, 1983).

  The updated 1977 Order was intended to increase the effectiveness of federal agencies' actions related to floodplain management. It also expanded the scope of E.O. 11296 by requiring that federal agencies also address the need to diminish environmental damage due to unwise planning and development of floodplains. (Similarly, E.O. 11990, Protection of Wetlands, which was issued at the same time, was intended to reduce the adverse impacts associated with the destruction or modification of wetlands.)

E.O. 11988 established general policy bringing together concerns for human health, safety, welfare, and property, with concerns for restoring and preserving natural and beneficial resources of floodplains. Federal agencies were directed to:

- avoid directly or indirectly supporting floodplain development;
- avoid actions located in or affecting the floodplain, unless the floodplain location is the only practicable alternative; and
- in the absence of a practicable alternative, require that actions be designed or modified in order to minimize potential harm to or within the floodplain.

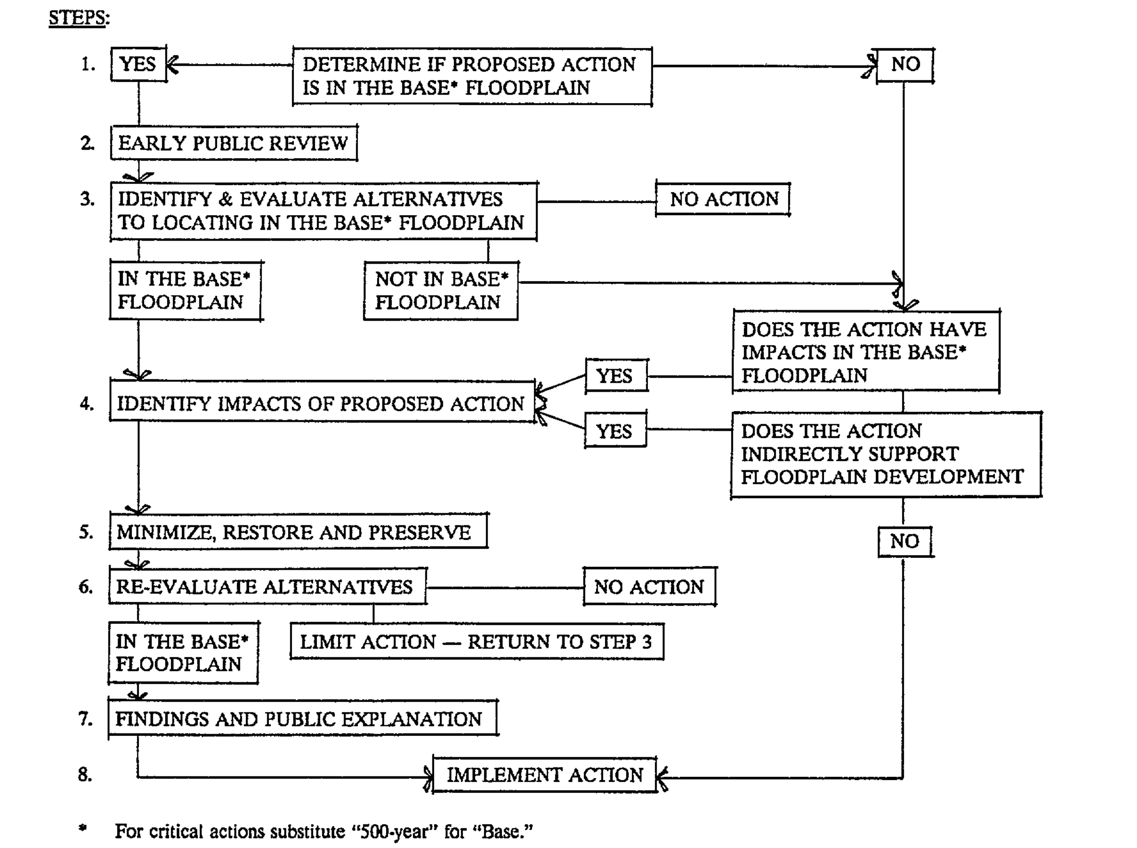
The Order, which applies to proposed actions of federal agencies, requires each agency to issue implementing procedures and provides for public participation in federal decisions affecting floodplains. As required by E.O. 11988, federal agencies taking actions affecting the floodplain are held to no less a standard than demanded by the federal government of communities participating in the NFIP.

1) WRC GUIDELINES FOR FEDERAL AGENCIES: In 1978, the U.S. Water Resources Council (WRC) issued a set of guidelines for use by federal agencies in implementing E.O. 11988. These guidelines were intended to provide broad guidance for interpretation of the Order, and to assist the federal agencies in developing their own procedures for complying with the Order.

   The WRC's guidelines, the result of a 12-month interagency task force effort, included an eight-step decision-making process (shown on Figure 11-2) to be followed by federal agencies in applying the Order to their actions.

   The Guidelines also spelled out the responsibilities of the agencies to: 1) recognize that floodplains have unique and significant public values, 2) evaluate the potential effects of any action that they may take in a floodplain, and 3) take floodplain management into consideration in formulating their own water and land-use plans, and in evaluating the water and land-use plans of others.

2) AGENCY PROCEDURES FOR IMPLEMENTING E.O. 11988. Executive Order 11988 included a requirement that federal agencies prepare procedures for implementing the directives of the Order. In 1982, in response to an Office of Management and Budget (OMB) request, FEMA conducted a review (Federal Emergency Management Agency, 1983) of the implementation of the Executive Order (as well as its associated one percent annual chance flood standard). In conducting its review, FEMA solicited comments from federal agencies on two questions regarding the Executive Order ("Are Federal agencies complying with E.O. 11988?" and "What impact, if any, has there been on the level of Federal support of unwise actions in designated floodplain areas?"), as well as six additional questions regarding agency compliance and effectiveness of the Order in achieving its purposes.



Source: U.S. Water Resources Council. Floodplain Management Guidelines for Implementing E.O. 11988. 43 FR 6030, February 10, 1978.

Figure 11-2. Eight-Step Decision-Making Process for Executive Order 11988.

FEMA's report included discussion of the status of agency implementing procedures and of numerous technical and procedural issues that had arisen in actual implementation. Among the major findings of the review were the following:

- Retention of the Order was strongly supported.

- Although the Order was successful in reducing exposure to potential flood losses, significant improvements in federal actions were still needed to achieve the objectives of the Order.

- Implementation procedures had not been adopted by all agencies and some agencies had adopted procedures inconsistent with the Order. Of 63 agencies, subagencies, and programs identified as requiring regulations or implementing procedures, 54 had adopted final or interim/final procedures as of February 1983 (in the form of regulations, internal directives, design manuals, etc.).

- Federal agency implementation had become more effective over time, but streamlining and other improvements to the implementation process were still needed.

3) Current Status of Implementation: As noted above, the 1983 review of implementation of E.O. 11988 concluded that the Order had been effective in reducing potential flood losses, but that improvements in both agency procedures and field implementation were still needed.

Although no systematic review of the status of implementation of the Order has been conducted since the 1983 FEMA review, informal discussions with several federal agencies indicate that the Order is considered effective within their agencies. However, little or no systematic tracking of agency decisions based on the E.O. guidance is available to verify these conclusions.

A Unified National Program for Floodplain Management (1986) noted that "Continued compliance and implementation of Executive Order 11988 Floodplain Management by all affected Federal agencies with endorsement by State and local governments are necessary if substantial savings from flood damages are to be achieved" (Federal Interagency Floodplain Management Task Force, 1986, Emphasis in original).

In 1987, the Federal Interagency Floodplain Management Task Force issued further implementation guidance for field-level staff in response to a recommendation in the 1983 review and to supplement the WRC's 1978 guidelines (Federal Interagency Floodplain Management Task Force, 1987). The Task Force will review this interim guidance document after approximately one year of use to determine if it requires revision before issuance as a supplemental guidance document.

In 1983, in accordance with E.O. 11988, the U.S. Environmental Protection Agency (EPA) agreed to provide federal funds for a sewer system only if the state and Worcester County, Maryland promised to deny sewer hookups for new development inside the "100-year" floodplain. The only exception to the ban was for property that had been platted for development before 1977, and existing homes and buildings.

A local property owner brought the issue to court, arguing that he needed sewer hookups to develop and that the State had the authority to restrict sewer hookups only if it was necessary to ensure that the treatment plant did not become overloaded. The Worcester County Circuit Court ruled that State and local government officials did not have authority to enter into the agreement with EPA. However, in June 1989 the Maryland Court of Appeals overturned the Circuit Court decision and upheld the agreement. The appeals court supported the State and local governments as having "made a rational determination ... that the federal grant proposal presented the most viable alternative available to abate the deteriorating conditions in West Ocean City." The court also noted that the property owner could develop the land by installing his own sewerage system and stated that "The burdens on ... [the owner's] rights are necessary and not unreasonable to promote the general public health and welfare" (Watson, 1989).

- **Principles and Guidelines.** The 1983 "Principles and Guidelines for Planning Water and Related Land Resources" require consideration of the potential of the floodplain for natural and cultural resources as part of the evaluation of alternatives for federal water resources projects. Nevertheless, the "Principles and Guidelines" can be an impediment to use of nonstructural measures as an alternative to or as part of structural flood control measures (Soil Conservation Service, 1989). The Principles and Guidelines require quantification of project costs and benefits to justify federal involvement. Many of the natural and cultural resources provided or protected by nonstructural measures — and often removed or modified by structural measures — cannot be easily quantified, and may not receive appropriate valuation during a benefit-cost evaluation.

- **Coastal Barrier Resources Act.** Concerns over past and possible future damage costs, along with environmental and public safety concerns and the realization that federal programs have historically encouraged and assisted development of barrier islands with resulting losses of natural, cultural, recreational, and other resources, led to the enactment of the Coastal Barrier Resources Act (P.L. 97-348) in 1982. This legislation was specifically designed to restrict federally subsidized development of undeveloped coastal barriers along the Atlantic and Gulf coasts in order to:

  - Minimize loss of human life;
  - Reduce the wasteful expenditure of federal revenues; and
  - Reduce damage to fish and wildlife habitat and other valuable natural resources associated with coastal barriers.

  The Act established the Coastal Barrier Resources System (CBRS), a system of largely undeveloped coastal barriers along the Atlantic and Gulf coasts. The barriers included in this system show a high degree of diversity in form (e.g., wave-dominated, tide-dominated, delta-formed, etc.) and function (e.g., eroding or accreting). Different regional coastlines within the system also exhibit a wide range of susceptibility to hurricanes and coastal storms.

  The Act prohibits, within the CBRS, most expenditures of federal funds that serve to promote economic growth and development. The major types of federal funds no longer available for use on the coastal barriers protected by this Act are: federal assistance for construction of sewer systems, water supply systems, airports, highways, bridges, jetties, seawalls and piers; federal flood insurance; Corps of Engineers' structural development projects; and Veteran's Administration and Federal Housing Administration loans.

  The expenditure limitation does not prohibit private financial transactions or the construction of facilities and structures with private funds or funds provided by state and local governments. The effect of the Act is to put the burden of financial risk associated with development on those who choose to live on coastal barriers, not on the taxpayer who, in the past, helped to bear this burden through subsidized federal flood insurance and emergency relief funds.

  The CBRA applies only to the largely undeveloped barriers within the designated Coastal Barrier Resources System because it was not the intent of the legislation to penalize existing communities but rather to remove incentives for future development. Barriers included in the CBRS were identified by geological criteria and through the political process at the local, state and federal levels.

The barriers protected stretch from Maine to Texas. No barriers in New Hampshire, Maryland, and New Jersey are included in the system. Massachusetts and Florida have the greatest numbers of separate coastal barrier units protected; Texas has the greatest acreage protected.

Section 10 of the CBRA required the Department of the Interior, in consultation with the states, to prepare and submit to Congress a report making recommendations for additions to, or deletions from, the CBRS, and for modifications to the boundaries of CBRS units. This report was completed in 1988. Table 11-7 summarizes the existing components of the CBRS and the changes that would result if the recommendations of the Department of the Interior are adopted by Congress (U.S. Department of the Interior, 1988).

The effectiveness of the Coastal Barrier Resource System (CBRS) in limiting development on sensitive coastal barriers is not clear. In many cases financing for coastal development can be obtained from private sources. Because of the demand for coastal property, turnover is so fast that developers have only a short time frame for financial exposure, and therefore little risk. Further, purchasers of buildings in areas included in the CBRS may not be aware that many forms of disaster relief will be unavailable if their property is damaged (U.S. Environmental Protection Agency, 1989).

State and Local Policies

State policies pertaining to floodplain development have been established through executive orders and coastal management policies. Road and bridge standards can also affect floodplain development.

- **Floodplain Management Executive Orders and Policies.** Several states have issued executive orders or other directives comparable to E.O. 11988 as a means of avoiding state expenditures to support floodplain development, and every state now has a statute or executive order to govern construction of state projects such as prisons and universities that are exempt from local regulations. Most of these were implemented to meet NFIP requirements. Many go beyond the minimum NFIP standards.

Ohio statutes require review of public facilities to be built by both state agencies and local governments.

All coastal states have some type of coastal management program that provides policies on development in coastal flood hazard areas.

Table 11-7. Summary of Department of Interior Recommendations for Changes in the CBRS.

STATE	NUMBER OF EXISTING CBRS UNITS	NUMBER OF UNITS WITH RECOMMEN-DATIONS	SHORELINE LENGTH IN CBRS (MILES)	SHORELINE LENGTH WITH RECOM-MENDATIONS (MILES)	TOTAL ACREAGE IN CBRS	TOTAL ACREAGE WITH RECOMMEN-DATIONS	FASTLAND ACREAGE IN CBRS	FASTLAND ACREAGE WITH RECOMMEN-DATIONS
Maine	12	25	10.0	22.5	1,045	4,640	485	1,005
Massachusetts	44	60	70.7	119.3	17,214	66,290	3,871	6,904
Rhode Island	11	20	17.7	25.7	4,791	8,851	1,058	1,436
Connecticut	11	15	8.2	7.5	3,045	3,741	333	302
New York	12	42	21.0	45.0	4,635	18,399	1,131	1,965
New Jersey	0	8	0	13.5	0	5,486	0	396
Delaware	2	4	17.1	17.5	1,565	6,945	517	740
Maryland	0	36	0	28.0	0	7,163	0	1,605
Virginia	4	52	13.8	80.5	11,298	52,831	1,148	3,479
North Carolina	8	6	54.6	32.6	31,913	29,741	8,610	4,579
South Carolina	13	14	38.4	42.4	26,885	76,130	4,511	4,586
Georgia	6	6	16.2	19.9	33,073	64,255	5,126	5,506
Florida	33	65	118.8	172.4	61,575	305,200	19,378	39,511
Alabama	3	4	17.6	19.0	10,678	11,058	2,940	2,722
Mississippi	4	6	9.6	12.8	4,309	5,981	557	662
Louisiana	12	17	91.7	180.0	59,243	353,340	4,518	12,747
Texas	11	19	161.0	180.0	181,565	199,401	46,751	48,498
Puerto Rico	0	42	0	56.9	0	21,486	0	2,473
Virgin Islands	0	20	0	13.4	0	2,740	0	587
TOTAL	186	461	666.4	1,088.9	452,834	1,243,678	100,934	139,703

Source: U.S. Department of the Interior, Coastal Barrier Study Group. Executive Summary in Report to Congress: Coastal Barrier Resources System. Washington, D.C.: U.S. Department of the Interior, 1988.

The Connecticut Coastal Management Program includes the policy to manage coastal hazard areas so as to insure that development proceeds in such a manner that hazards to life and property are minimized. The Coastal Management Program also contains the following policies applicable to coastal hazard areas (State of Connecticut, 1979):

- To promote nonstructural solutions to flood and erosion problems except in those instances where structural alternatives prove unavoidable and necessary to protect existing inhabited structures, infrastructure facilities, or water-dependent uses.
- To maintain the natural relationship between eroding and depositional coastal landforms.
- To minimize the adverse impacts of erosion and sedimentation on coastal land uses through the promotion of nonstructural mitigation measures.
- Structural solutions are permissible when necessary and unavoidable for the protection of infrastructure facilities, water-dependent uses, or existing inhabited structures, and where there is no feasible, less environmentally damaging alternative, and where all reasonable mitigation measures and techniques have been provided to minimize adverse environmental impacts.

North Carolina has imposed strict regulations on development within coastal hazard areas. Through the state's Coastal Area Management Program, guidance and financial assistance is provided to coastal counties for local land-use planning. Local plans must be prepared in conformance with state-established guidelines and must include policies on a range of specified issues, including resource protection, economic and community development, and storm hazard protection.

In addition to the local land-use plans, a second major component of the State coastal program is delineation and regulation of Areas of Environmental Concern (AECs). In AECs, development must be reviewed and approved by either the Coastal Resource Commission (major developments) or by the local government (usually for minor developments), and must be consistent with state performance standards for each type of AEC and with local land-use plans.

Two types of estuarine category AECs (coastal wetlands and estuarine shorelines) and three types of ocean hazard AECs (ocean erodible, high hazard flood, inlet hazard areas) are particularly significant with regard to the management of development subject to hurricanes and storm hazards. In ocean erodible zones, for example, structures are subject to a setback requirement that is related to the first line of stable natural vegetation and long-term erosion rate. Inlet hazard areas extend landward from the mean low water line to cover an area of potential inlet migration.

Some examples of State-established performance or use standards that guide development and redevelopment in North Carolina's AECs are:

- an increase in the setback distance (in addition to the rule for setback behind primary and/or frontal dunes) for larger oceanfront uses such as motels, hotels and condominiums;

- in ocean hazard areas, no development which involves significant removal or relocation of sand or vegetation of frontal or primary dunes;

- construction or substantial improvement in ocean hazard areas must satisfy additional standards for windstorm resistant construction as well as elevation and piling requirements; and

- development in estuarine shorelands restricted from producing impervious surfaces exceeding 30% of the AEC land (Brower, 1986).

- **Roads and Bridges.** States exhibit great variability with regard to road and bridge design and construction standards. The minimum requirements of the NFIP only restrict construction of roads and bridges if they create a floodway encroachment. While interstate highways must meet higher standards, the Federal Highway Administration (FHWA) requires that federal-aid highways meet the NFIP standard and will provide financial assistance to states in accordance with those standards. Additional costs resulting from a more restrictive standard must be borne totally by the state (Myers, 1989).

  Several states require more stringent standards for roads and bridges not on the federal-aid system. Some states' standards are based on economic analyses dependent on site conditions.

Indiana requires state and local roads to pass a one percent annual chance flood, although the road can be inundated.

Under Florida statute, no State money can be spent to construct a bridge to a coastal barrier island that did not have a bridge on October 1, 1985.

Kansas allows state and local roads to pass only the four percent annual ("25-year") flood, but there must be three feet of freeboard.

Table 11-8 identifies those states that have adopted standards or policies that are more stringent than required by the NFIP regarding construction of state or local roads and bridges (Association of State Floodplain Managers, 1988).

Table 11-8. States with Road and Bridge Standards that Exceed NFIP Requirements.

	ROAD & BRIDGE STANDARDS	
	STATE ROADS	LOCAL ROADS
Alabama		
Alaska		
Arizona	X	
Arkansas	X	
California	X	X
Colorado	X	
Connecticut	X	
Delaware		
District of Columbia	X	X
Florida	X	X
Georgia		
Hawaii		
Idaho		
Illinois	X	X
Indiana	X	X
Iowa	X	X
Kansas	X	X
Kentucky		
Louisiana		
Maine	X	
Maryland	X	
Massachusetts		X
Michigan	X	X
Minnesota	X	X
Mississippi	X	X
Missouri	X	
Montana	X	X
Nebraska	X	X
Nevada		
New Hampshire	X	
New Jersey	X	X
New Mexico		
New York	X	
North Carolina		
North Dakota		
Ohio	X	X
Oklahoma	X	
Oregon		
Pennsylvania	X	
Rhode Island	X	
South Carolina	X	
South Dakota		
Tennessee		
Texas	X	X
Utah	X	
Vermont	X	
Virginia	X	
Washington		
West Virginia	X	
Wisconsin	X	X
Wyoming	X	

Source: Association of State Floodplain Managers. "State Floodplain Management Programs. Results of a Survey Conducted by the Association of State Floodplain Managers for L.R. Johnston Associates," 1988.

LAND RIGHTS, ACQUISITION AND OPEN SPACE USE

Regulations and policies affecting the design and location of services and utilities may be satisfactorily applied to avoid or reduce inappropriate development in many floodplains. However, this approach is not adequate for all types of floodplains or for all occasions. In particular, regulation and development policies have considerable limitations for protecting natural resources or for obtaining public use of properties. Where natural resources must be protected, public use of the land is desired, or if there are strong development pressures, acquisition of the land may be the only means of obtaining desired objectives.

Full title to land may be acquired, or control of the land may be acquired through easements or development rights; all for the purpose of precluding future uses incompatible with the flood risk and open space use. In the short term, acquisition of land or land rights may be a costly substitute for regulation. Long-term benefits may outweigh the short-term costs, however, and acquisition may be the only acceptable approach if the proposed use has a specific nonflood-related purpose, such as for public use areas. (Federal Interagency Floodplain Management Task Force, 1986).

The literature carries only limited examples of land rights acquisition[6] for the sole or primary purpose of flood loss reduction.[7] To develop favorable support for acquisition projects, government officials typically will include all potential benefits of property acquisition as justification for the project, including such benefits as protection of wetlands and other habitat resources and scenic resources, as well as water quality, recreation, and flood loss reduction benefits.

Section 73 of the Water Resources Development Act of 1974 provided for full consideration of acquisition and other nonstructural measures for flood control. Cost-sharing for nonstructural measures is the same (25% nonfederal) as for structural projects. Still, land rights acquisition is not widely used for flood loss reduction. The high cost of land and concerns over excessive government ownership of land and/or taking of private property appear to be contributing reasons.

Perhaps the most prominent example of federal land acquisition specifically for flood loss reduction purposes is the Charles River Watershed in Massachusetts. To reduce flood losses in the lower Charles River Watershed, the Corps of Engineers acquired land in the upper watershed to provide flood storage capacity.

The high cost of coastal property has made acquisition of this land particularly difficult, especially land with potential for development. Practically the only coastal land that can be purchased is that in wetlands or some other restricted category. When coastal land is acquired, flood loss reduction is usually only one of several project objectives.

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6 Acquisition of property with structures subject to flood damage is far more common. This application is described later in this chapter in the section on Permanent Evacuation.

7 Land acquisition is an integral part of most structural flood control measures which are described in Chapter 12.

Further description of land acquisition to preserve open space, protect floodplain natural resources, and reduce future flood losses is provided in Chapter 14.

REDEVELOPMENT

Redevelopment may offer opportunities for reducing vulnerability to flood losses as well as improving blighted or uneconomical development. Only infrequently is flood damage reduction the sole motive for redevelopment. Nevertheless, sound floodplain management principles can be applied to practically any redevelopment within the floodplain. (Federal Interagency Floodplain Management Task Force, 1986).

Federal Programs for Redevelopment

The federal government promotes redevelopment primarily through grants, loans and technical assistance to state and local governments, rather than by engaging directly in redevelopment projects. During the 1970s, the Department of Housing and Urban Development (HUD) provided several programs aimed at redevelopment of urban and blighted areas. Among the programs available to assist states and local communities were the 701 planning program and the urban redevelopment program. These particular programs were eliminated in the 1970s and largely replaced with revenue-sharing programs, most specifically the Community Development Block Grant (CDBG) program. CDBG funds have been used by many communities throughout the country to assist with redevelopment projects involving floodplains.

State and Local Activities

Although federal agencies often contribute significantly through funding and technical assistance, redevelopment is primarily a function of state and local governments and the private sector. Much redevelopment of floodprone areas has been associated with a rediscovery of and reorientation toward the urban waterfront. Major waterfront redevelopment in Baltimore, Boston, Pittsburgh, and San Antonio have helped to revitalize existing urban areas. Areas that were once blighted have been redeveloped and turned into major economic resources. This same type of waterfront development has taken place on a much smaller scale in many other locations around the country.

Most redevelopment relating to flood loss reduction occurs following a major flood or a series of floods. If the development continues to occupy the floodplain, then typically some type of localized structural measure is undertaken to accompany the redevelopment or floodproofing of structures. A temporary moratorium may be imposed to allow proper evaluation and planning prior to permitting any redevelopment (see the section on Postflood Recovery in Chapter 13). Redevelopment primarily for flood loss reduction purposes is associated with permanent evacuation of the floodplain (see following section).

Of course, not all redevelopment conforms to accepted floodplain management practices. From expansion or reconstruction of individual homes to revitalization of entire neighborhoods, redevelopment often fails to incorporate actions that would reduce the flood hazard. Unfortunately, this is often the case following a damaging flood. In the rush to restore normalcy to the lives of individuals and entire communities, redevelopment often leaves an area just as vulnerable to flooding as it was before the flood. Too often, legislative and regulatory requirements actually encourage — or even require for some forms of financial assistance — redevelopment to preflood conditions, and opportunities to mitigate against future flood losses are lost.

PERMANENT EVACUATION

Permanent evacuation of a portion of a floodplain is usually associated with some type of redevelopment in another, nonfloodplain location. Many individuals and organizations have proclaimed the need to remove structures and inappropriate uses from flood risk areas, but achieving such action can be difficult. Consequently, permanent evacuation is currently less common than other tools except perhaps for small, isolated sectors of nonconforming uses. Permanent evacuation of the floodplain typically occurs only when the flood risk is exceptionally great or frequent and no structural protection is practical. In some cases, permanent evacuation may result from a combination of reducing flood risk and achieving other community goals at the same time.

The Federal Interagency Floodplain Management Task Force has noted that permanent evacuation may be the only economically viable alternative in some instances (Federal Interagency Floodplain Management Task Force, 1986). The Task Force recommended that, "to the extent permitted by statute, Federal agencies should provide encouragement for relocation of structures and facilities from floodways and perilous floodprone areas, leaving such areas for open space uses." Even in instances when permanent evacuation is not feasible, it provides a standard by which other flood loss reduction tools may be evaluated.

Federal Activities

Historically, most federal activity related to permanent evacuation of floodplains was limited to specific projects. Permanent evacuation was, and still is, often a part of structural flood control projects. Individual structures, groups of structures, and even entire small communities have been permanently removed from the floodplain so that a structural project can proceed. Occasionally, permanent evacuation has been selected as an alternative to a structural project. In these instances, floodprone structures have been either purchased and demolished, or relocated out of the floodplain.

Programs that involve acquisition and permanent evacuation of developed floodplains often need to provide some type of financial and/or technical assistance in relocation. If federal funds are used for acquisition of any occupied properties, the guidelines established in the Federal Relocation Assistance and Real Property Acquisition Policies Act of 1970 will normally need to be followed. The federal relocation assistance law requires, and state laws may also require, the payment of moving expenses and "replacement housing payment" consisting of any additional money beyond the fair market value of the acquired structure that is required for a displaced resident to purchase decent, safe, and sanitary housing outside the floodplain. Because it is a voluntary program, FEMA's Section 1362 program offers no specific financial assistance for relocation (Field, 1981).

- **Congressionally authorized projects.** A few permanent evacuation projects have been specifically authorized by Congress. Prairie du Chien, Wisconsin is probably the best known example.

Portions of the Town of Prairie du Chien, including much of the original development, were located in the floodplain of the Mississippi River. Floods have been a recurring problem, and following a particularly devastating flood in 1965, the Town requested the Corps to conduct a flood protection study. The Corps found structural measures to be too expensive, and the plan developed by the Corps, approved by the Town, and authorized by Congress, involved the evacuation of all residences and two businesses in the "10-year" floodplain. All other businesses were allowed to remain.

The plan included relocation assistance to those evacuated, technical assistance to owners of remaining floodplain properties who wished to floodproof their structures, continued floodplain regulation, and continued availability of flood insurance. The Town is responsible for maintaining the evacuated area in its intended reuses — open space recreation and a historical tourist attraction (Field, 1981).

1) FUNDING AND TECHNICAL ASSISTANCE PROGRAMS: Several federal programs have been available at various times to provide technical and/or funding assistance for property acquisition and permanent evacuation of the floodplain. Most notable among these has been HUD's Community Development Block Grants (CDBGs). Other programs or funding sources used include the Secretary of the Interior's discretionary fund; the Secretary of HUD'S discretionary fund; Land and Water Conservation Fund (LWCF) administered by the Department of Interior; disaster, business, and home repair loans from the Small Business Administration (SBA); and emergency loans from the Farmers Home Administration (FmHA); among others.

2) SECTION 1362 OF THE NFIA: Section 1362 (Flooded Property Acquisition Program) of the National Flood Insurance Act authorized acquisition of selected flood-damaged properties. However, it was not until after legislative modifications were made in 1973 and a feasibility study was conducted beginning in 1976 that the program was implemented.

   The 1979 implementation of Section 1362 signaled a new approach by the federal government for reducing flood losses. Section 1362 authorizes the acquisition of flood damaged properties, subject to several restrictions. All properties must have been covered by flood insurance at the time the flood damage occurred, and the property must have been damaged by a single flood event to at least 50% of value, or damaged three times in five years to at least 25% of value. Program funds can be used to acquire the lot on which a flood damaged structure is located, but cannot be used to acquire vacant land. The program negotiates for the acquisition based on preflood fair market value, less any payments for flood insurance claims.

   Land acquired with Section 1362 funds must be converted to some type of open space use. Communities participating in the program must submit an acceptable project application to FEMA, and commit to maintaining a reuse plan and to clearing the damaged structure(s) from the site. Although title to acquired property is temporarily transferred to FEMA, permanent title is transferred from FEMA to either the local government or to a unit of state government.

The Section 1362 program was first funded in 1980 at a level of $5.4 million. As shown in Table 11-9, funding has ranged from a low of $1.6 million to a high of about $6.8 million. Through fiscal year 1988, a total of 797 properties had been acquired and 1,251 structures were approved for acquisition. Of the total $42,063,601 appropriated for the program, $23,502,368 had been spent for acquired structures ($25,977,762 including administrative costs) (MacKay, 1988). Acquisition of flood-damaged properties, however, is not always without difficulty, no matter how serious the flood risk (see the example from the State of Texas on the next page).

The Section 1362 program has proved popular with states and communities because its implementation has resulted in open space use in flood hazard areas. In most years since the program was first funded, the number and dollar value of potential community applications has exceeded the available funds. Recommendations by governments at all levels and by professional organizations that Congress increase the funding level have proven unsuccessful.

Table 11-9. Section 1362 Appropriated Funds.

FISCAL YEAR	APPROPRIATED FUNDS	FUNDS SPENT(a)
1980	$5,400,000	$5,951,867
1981	5,400,000	3,591,867
1982	1,600,000	1,402,632
1983	4,334,353	4,708,124
1984(b)	6,778,000	4,813,370
1985	4,778,000	4,813,370
1986	4,522,248	566,867
1987	4,720,000	3,080,881
1988	4,531,000	
TOTAL	$42,063,601	$25,977,762

(a) Includes funds for administrative costs.
(b) Fiscal year program authorized two-year funding. In 1984, a one-time $2,000,000 supplemental appropriation was made available.

Source: MacKay, Ross. Federal Insurance Administration. Personal communication, 1988.

The Brownwood subdivision on a peninsula in Baytown, Texas contained some 300 homes built in the 1950s. The extent of the flood hazard in the area was first realized in 1961 when Hurricane Carla resulted in eight-foot deep flooding in the subdivision. Since that time, the area has continued to subside (five feet between 1963 and 1985) to just above sea level, and tidal flooding occurred frequently (including five flood alerts and four evacuations in 1979 alone). Although homeowners had experienced frequent tidal flooding (and submitted repeated flood insurance claims), they were unprepared for the strength of Hurricane Alicia in August 1983. More than 600 housing units in Baytown were destroyed, half of them in the Brownwood subdivision. Because of the extent of the flood damages, as well as the history of repeated damages and insurance claims, the city and FEMA decided to acquire the properties in Brownwood through the Section 1362 Acquisition Program. The City passed an ordinance preventing repairs and occupancy of structures in the Brownwood area, thus qualifying all homes there for Section 1362.

Although most property owners were initially in favor of the acquisition program, many later became suspicious of the effort (e.g., there were rumors that the City intended to resell the properties to industry at a profit). In addition, others changed their minds because of the long waiting period (the first purchases were not made until seven months after the storm) and the low values offered for the properties (in some cases only the $1000 - $2000 value of the lot). Two homeowner groups sued the City for large amounts, claiming that the City's regulatory ordinance prohibiting repairs and occupancy of structures in the Brownwood area was a "taking" of property. Eventually, despite all the problems and even though all property owners were not satisfied, 177 of 265 homes eligible for acquisition were purchased under the 1362 Program (Strong, 1985).

- **Housing and Community Development Act of 1987.** Section 544 (commonly referred to as the Upton/Jones provisions) of the Housing and Community Development Act of 1987 (P.L. 100-242) authorized payment of flood insurance claims prior to actual damage to a structure if the structure was found to be in imminent danger of collapse due to coastal erosion.

  Prior to passage of the Upton/Jones amendment, such structures had to literally fall into the water before a claim could be paid under the flood insurance policy. Under this amendment, any structure covered by flood insurance, located on the shore of a body of water, and subject to imminent collapse or subsidence as a result of erosion or undermining may be eligible for claims payments. The Federal Insurance Administration determines final eligibility after certification by an appropriate state or local land-use authority that the structure is subject to "imminent collapse or subsidence as a result of erosion or undermining caused by waves or currents of water exceeding anticipated cyclical levels." If the structure is demolished, payment can be for up to 110% of the value of the structure or actual demolition costs. For relocated structures, payment of 40% of the value of the structure is authorized. If collapse occurs before demolition or relocation, and no effort had been made to demolish or relocate, payment is limited to 40 percent of the value of the structure.

Structures are not eligible for these payments unless covered by a flood insurance policy in effect: a) on or before June 1, 1988; b) for a period of two years prior to certification of "imminent collapse"; or c) for the term of ownership if less than two years. Reconstructed or relocated buildings must be set back from the water. Structures with one to four dwelling units must be set back a distance greater than 30 times the average annual erosion rate. Other structures must be set back 60 times the average annual erosion rate (Association of State Floodplain Managers, 1988).

In July 1988, the National Academy of Sciences (NAS) began a one-year study to review some of the issues related to carrying out this program. The NAS report recommended a possible methodology for determining coastal erosion rates to determine when a structure is subject to "imminent collapse or subsidence" (Simmons, 1988). The Federal Insurance Administration (FIA) implemented interim rules for the program effective in September 1988 (Federal Emergency Management Agency, 1988). As of November 1990, 381 claims had been referred to the FIA under this program, of which about half had been approved for payment (80% of which were for demolition). Twenty-three percent of the claims were for riverine areas (Federal Emergency Management Agency, 1990).

State and Local Activities

More and more states are promoting and funding acquisition as an effective method to redevelop a floodprone area.

Minnesota assisted four communities in relocating buildings out of the floodplain and then wrote a brochure on the local experiences for distribution to other towns. In 1987, the Minnesota Legislature created an ongoing program for flood damage reduction assistance which provides matching funds for a variety of community actions, including relocation of floodplain structures.

Louisiana's Flood Control Act provides for a 50/50 cost sharing with local units of government for flood mitigation projects, including levees, dikes, dams, and relocation of structures.

Maryland estimates that 380 properties have been acquired over the last six years as a direct result of 50% state funding (Association of State Floodplain Managers, 1988).

In addition, the Commonwealth of Puerto Rico authorized $36 million for an island-wide mitigation project that will be implemented entirely without federal aid. Coastal protection of ports and industrial areas with flood control structures will be complemented by the relocation of 1,400 families living in high hazard areas (Federal Emergency Management Agency, 1987).

Many other states have general purpose redevelopment funding programs, such as the Community Development Block Grant. Land acquisition programs for open space or recreation are included because they generally give priority to waterfront property and the land is maintained as open space free from flood damage. Open space funds are frequently obtained through bonding, and the State of Maine recently passed a $35 million bond referendum for land acquisition (Association of State Floodplain Managers, 1988).

Local governments may also initiate redevelopment projects that involve permanent evacuation of the floodplain. Many of these local projects were undertaken following devastating floods, and involved substantial financial and technical assistance from federal and state agencies.

In Soldiers Grove, Wisconsin, the Corps of Engineers planned and began construction of an earthen dam to protect downstream communities from flooding of the Kickapoo River. However, the dam would not have provided complete protection for the Village of Soldiers Grove, and to provide full protection, the Village would have had to share in the construction costs of two massive levees running through the downtown area. For this and other reasons, opposition to the dam prevented the project from being completed.

The Village of Soldiers Grove decided to relocate its central business district outside of the floodplain. A devastating 1978 flood accelerated the planning and implementation of the relocation project. The village spent its own funds to acquire a new site for the central business district, and began obtaining commitments of federal and state assistance. Commitments were obtained from the Department of Commerce's Economic Development Administration, to assist with installing sewer and water lines to the new area; HUD Secretary's Discretionary Fund; Department of the Interior's Secretary's Discretionary Fund; state Community Development funds; and state Natural Resources funds (Field Associates, 1981).

Other local projects involving permanent evacuation from the floodplain have been accomplished primarily or entirely with local funds.

Baltimore County, Maryland suffered serious flooding problems for decades. Following especially severe flooding in the early 1970s, the county examined ways to deter future flooding. Acquisition and permanent relocation were found to be the most cost-effective approach in six of eight watersheds studied. The county was able to determine that its previous costs for stormwater drainage improvements had averaged $4.5 million annually. The acquisition program, which would eliminate these stormwater costs, was scheduled over a six-year period to avoid any increase in annual expenses (Field Associates, 1981).

EFFECTIVENESS OF DEVELOPMENT AND REDEVELOPMENT POLICIES

Strong policies regarding avoidance of inappropriate floodplain development are widely regarded as necessary and important floodplain management tools. Policies incorporated into legislation, such as the National Environmental Policy Act, are generally viewed as more effective than policies embodied in executive orders or administrative guidance. When an administrative policy conflicts or is perceived as conflicting with a legislative mandate, the policy is less likely to be implemented. For example, E.O. 11988 has been implemented effectively by those agencies that viewed its provisions as supporting other agency programs and missions. It has had less impact on agencies such as HUD and the Federal Highway Administration which find its provisions sometimes at odds with mandates to provide low-income housing and essential transportation links. Similarly, informal agency policies to promote mitigation following flood disasters have often been stymied by legislative provisions that require redevelopment to preflood conditions. Policies may help to provide needed direction when legislative mandates are subject to interpretation, but to be most effective, policy needs to be translated into legislative and regulatory requirements.

Not all states have strong policies regarding development and redevelopment in floodplains and sensitive natural resource areas. The EPA has suggested that every state should have a public environmental review process similar to the process established by the National Environmental Policy Act (U.S. Environmental Protection Agency, 1989). Exemptions from general policies regarding avoidance of inappropriate development in floodplains is a weakness of many state policies. Exemptions apply to activities ranging from road and bridge construction to agricultural activities. The cumulative floodplain areas affected by these exemptions can be large and the impact of flood risk and loss of natural resources significant.

DISASTER PREPAREDNESS

Disaster preparedness encompasses a broad spectrum of activities, including plans and programs for predisaster mitigation, warning and emergency operations; training at all levels; public information activities; exercises to test disaster preparedness plans; and readiness evaluations. Other concerns include research, review and coordination of federal, state, and local disaster preparedness plans and programs, and post disaster evaluation. The effectiveness of disaster preparedness is dependent on the degree to which individuals, local governments, and states implement the plans. Preparedness plans often are developed in concert with flood forecast, warning and emergency plans (see following section). While it is most desirable to develop preparedness and recovery programs prior to flood disasters, the opportunity should be seized when such disasters do occur to design and implement recovery and redevelopment activities that will reduce or eliminate future flood hazards (Federal Interagency Floodplain Management Task Force, 1986).

FEDERAL ACTIVITIES FOR DISASTER PREPAREDNESS

The federal role in disaster preparedness includes regulatory requirements, technical assistance, and funding. Major federal disaster preparedness activities are described on the following pages.

Disaster Preparedness Improvement

Under the authority of Section 201(d) of the Disaster Relief Act of 1974, FEMA provides up to 50 percent matching grants to assist states in developing and improving state and local plans, programs, and capabilities for disaster preparedness and mitigation. The program promotes development of integrated emergency preparedness plans that address all types of natural and technological hazards. This concept, known as the Integrated Emergency Management System (IEMS), has evolved from earlier civil defense planning. The IEMS program is based on the idea that preparedness needs for all types of natural and technological hazards is very similar, even though the details may vary for each type of hazard. FEMA has developed extensive guidance for state agencies to use in preparing integrated emergency management plans (Federal Emergency Management Agency, 1987).

For many years funding was provided to states at the level of $25,000 per year. The Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988 (P.L. 100-707) increased the level of authorized funding to $50,000 per state each year.

Interagency Flood Hazard Mitigation Teams

In December 1980, in response to a July 1980 directive issued by the Office of Management and Budget (Office of Management and Budget, 1980), 12 federal agencies signed an Interagency Agreement to provide technical assistance to states and communities for nonstructural flood damage reduction measures (Interagency Agreement, 1980). Representatives from each agency formed an Interagency Flood Hazard Mitigation Task Force charged with carrying out the terms of the agreement. The Task Force representatives ensure that technical personnel from their agencies are available to participate on postdisaster interagency hazard mitigation teams, and review agency programs and policies in order to identify and remove obstacles to implementation of flood hazard mitigation measures recommended by the interagency teams.

Following each major flood disaster declared by the President,[8] an Interagency Flood Hazard Mitigation Team is formed to provide technical assistance and guidance to communities and states affected by the disaster. A FEMA representative leads the interagency team, and calls upon representatives from each of the 12 federal agencies, as needed, to participate on the interagency team. The exact makeup of the team is determined largely by the type of damages incurred. Typically state and local representatives also participate on the interagency teams.

Within 15 days after a disaster declaration, the interagency team prepares a report identifying flood hazard mitigation measures that may be implemented in the affected areas. These reports provide local and state officials, as well as federal agencies, an opportunity to take mitigation actions before the recovery process has proceeded too far and many mitigation opportunities have been lost. A follow-up report by the interagency team is prepared 90 days after the disaster declaration to assess the extent to which its recommendations have been implemented, and to try and identify and resolve any obstacles to implementation (Federal Emergency Management Agency, 1981). There has not been any recent systematic review of the extent to which recommendations of the hazard mitigation teams have been implemented by state and local governments.

While the OMB memorandum and the Interagency Agreement also call for federal technical assistance for predisaster planning, to date little or no predisaster planning assistance has been provided under this provision.

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8 Teams may also be formed in the absence of a Presidential declaration — for less disastrous flood events and for predisaster planning — but typically are used only after a Presidential declaration.

Section 409 Hazard Mitigation Plans

Under Section 409[9] of the Stafford Act, any jurisdiction that receives federal disaster assistance must prepare a hazard mitigation plan within 180 days of the disaster declaration. If the state fails to meet requirements under this section, future federal assistance may be curtailed. Regulations for implementing Section 409 were first issued in 1979.

Since state and local mitigation planning was initiated in 1980 in response to the Section 409 requirements, most states have gained some experience in planning for and implementing hazard mitigation measures. The level of quality and effectiveness of the programs developed, however, has varied considerably from state to state. As noted in a 1986 FEMA guidance document (Federal Emergency Management Agency, 1986), some states have used the Section 409 requirements as a "spring board" to more comprehensive planning and implementation. In other jurisdictions, only minimal plans have been prepared, and there have also been some difficulties in program administration (e.g., deadlines for completion of plans have sometimes not been met). In some instances, preparation of a Section 409 plan has been undertaken merely to meet the requirement, and only limited follow-up activity has been directed toward program development.

FEMA has provided several forms of guidance on the Section 409 planning process. In addition to the formal regulations (44 CFR Part 206, Subpart M), interim guidance has been provided to states on suggested content and format of Section 409 plans, training programs have been offered at FEMA's Emergency Management Institute, and several published FEMA documents include guidance related to Section 409 plans. The *Making Mitigation Work* (Federal Emergency Management Agency, 1986) handbook was intended to serve as an orientation manual for acquainting the state Hazard Mitigation Coordinator with some of the basic programs, processes and requirements for accomplishing mitigation (but not as a step by step guide to meeting Section 409 planning requirements). FEMA has also issued mitigation guidance through the Integrated Emergency Management System series of publications. In addition, the 1981 *Flood Hazard Mitigation Handbook of Common Procedures* (Federal Emergency Management Agency, 1981) prepared for Interagency Regional Hazard Mitigation Teams provides guidance for the teams to use in preparing their reports, which are often used in the development of Section 409 plans. In September 1990, FEMA published a handbook on Section 409 hazard mitigation planning entitled *Post-Disaster Hazard Mitigation Planning Guidance for State and Local Governments* (DAP-12) (Federal Emergency Management Agency, 1990).

Hurricane Preparedness Program

The need for hurricane evacuation studies arose with the rapid and large population growth experienced in coastal areas over the last 20 years. All levels of government became increasingly concerned about the relative complacency of coastal residents to hurricane threats. It was clear that the ability to prepare and react to major coastal storms had to be refined and improved. To do so, reliable data was needed to help state and local emergency managers make well-informed decisions.

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[9] The Disaster Relief and Emergency Assistance Amendments of 1988 resulted in a renumbering of sections, and Section 406 was changed to Section 409.

FEMA, the Corps, and the National Weather Service (NWS) joined together to carry out a program of comprehensive hurricane evacuation planning in association with states along the Atlantic and Gulf coasts. NWS develops the SLOSH model for each coastal basin under its Hurricane Preparedness Program. FEMA funds the running of the SLOSH models for each basin by the NWS's National Hurricane Center (NHC), which produces data on surge elevations and the arrival of gale force winds at selected points within each basin for a sequence of storm directions, speeds, and intensities. The Corps and FEMA jointly fund, manage, and coordinate the studies. The Corps conducts the studies, using its own personnel, and in some cases contractors for specialized efforts.

Comprehensive Hurricane Evacuation Studies are prepared from exhaustive research and provide detailed information on a broad spectrum of storm potentials. They evaluate areas vulnerable to destruction and flooding from storm surges and estimate the arrival time of gale force winds. Based on those predictions, the Corps prepares detailed maps dividing impacted areas into zones depending on the storm intensity. Within each zone, population data, evacuation routes, available shelters, and medical facilities are studied. Behavioral research is performed to predict what percent of the population would comply with ordered evacuation and what their likely routes and destinations would be. These data are then used to determine the time required to respond and evacuate the affected zones for each hurricane scenario.

Throughout the study process, local and state emergency planners are closely involved. They review the study phases, provide input and react to the concepts presented. This insures that the final results are relevant to the particular plans and resources of each local official. The close coordination produces a document and decision-making tools, and gives the emergency manager the benefit of the latest technology in hurricane planning.

The value of Comprehensive Hurricane Evacuation Studies was particularly evident in 1989 during Hurricane Hugo when hundreds of thousands of people were evacuated from areas devastated by the storm, and loss of life was kept to a minimum. Hurricane Evacuation Study results were integrated in the state and local emergency preparation plans and used to evacuate extensive areas along the coasts of South Carolina, North Carolina, and Georgia. Advance study data were also used in evacuating areas in San Juan, Puerto Rico. The extent of injuries and fatalities from Hurricane Hugo would have been far greater if affected areas had not had a high degree of preparedness. This readiness was significantly enhanced by the planning partnership forged between FEMA, the Corps, NWS, and the individual states.

Comprehensive Hurricane Evacuation Studies require three to four years to complete, depending on size, complexity, and availability of funding. Studies cost between $500,000 and $700,000. Table 11-10 shows the status and funding levels of the on-going joint Hurricane Evacuation Studies, as well as funding and time-frame data for completed studies as of October 1989 (Peterson, 1989).

Other Federal Programs and Activities

In addition to the activities described above, federal agencies have been and continue to be involved in providing disaster preparedness funding and technical assistance to state and local governments in many ways. Several examples illustrate the range of these activities.

Table 11-10. Status of Hurricane Evacuation Studies.

STATUS OF JOINT FEMA, CORPS, NWS HURRICANE EVACUATION STUDIES
OCTOBER 1989

		AREAS STUDIED	PROJECT STATUS				COST ($000)			
			Completed		Underway		Completed		Underway (est.)	
Div.	Dist.	Community	Start	Compl.	Start	Compl.	Total	Corps	Total	Corps
SAD	SAC	South Carolina Coast	3/84	4/87			544	174		
	SAJ	San Juan, PR			9/87	12/90			189	95
	SAJ	Lee Co., FL	1/78	5/79			120	120		
	SAJ	Tampa Bay Regional	6/79	6/81			300	300		
	SAJ	SE Fla.	12/80	6/83			378	328		
	SAJ	SE Fla. Restudy			8/87	12/90			440	150
	SAM	Tri-States(MS,AL,FL)	9/83	9/86			640	90		
	SAS	Georgia Coast	10/85	9/89			526	206		
	SAW	North Carolina Coast	3/84	12/87			537	232		
	SAW	Long Island, NY			FY 86	FY 92			775	310
		SAD TOTALS					3045	1450	629	245
NAB	NAB	Maryland Coast			FY 85	FY 90			695	300
	NAO	Virginia Coast			FY 85	FY 91			715	275
	NAP	Delaware Coast	FY85	FY89			468	233		
	NAP	New Jersey Coast			FY 85	FY 90			685	325
		NAD TOTALS					468	233	2095	900
	POD	Southern Oahu	FY84	7/88			351	121		
POD	POD	Windward Oahu			7/89	FY 91			250	100
		POD TOTALS					351	121	250	100
	LMN	SE Louisiana Coast			FY 87	FY 90			431	115
LMVD										
	NED	Connecticut Coast			FY 86	FY 92			575	275
NED	NED	Rhode Island Coast			FY 87	FY 93			450	200
	NED	Massachusetts Coast			FY 87	FY 93			450	200
		NED TOTALS							1475	675

Source: Peterson, Jerome. Chief, Floodplain Management Services, U.S. Army Corps of Engineers. Personal communication, 1989.

- **Hazard Mitigation Assistance Program.** Beginning in 1985, FEMA began providing limited funding (approximately $200,000 per year) for grants to states for conducting hazard mitigation projects. These projects may involve disaster preparedness or may be more directly related to disaster recovery and mitigation. "... Over the last 3 years, this program has provided $600,000 to states for new and innovative mitigation projects. With this relatively small amount of money, FEMA has funded over 36 projects in 26 states ... which has proven to be the catalyst to initiate mitigation programs in these states and many communities" (Watson, 1988).

Several examples are listed below to illustrate the range of activities funded under this program (Stallschmidt, 1987):

- City of Shelton, Connecticut: To develop a plan to acquire and remove a group of 56 structures which are located in the floodplain of the Housatonic River and are subject to annual flooding.

- West Virginia Office of Emergency Services: To hold a two-day flood recovery and mitigation forum for West Virginia local officials to discuss the application of successful mitigation recovery strategies with nationally recognized mitigation experts.

- Kentucky Flood Control Advisory Commission. The Flood Control Advisory Commission and the Kentucky Housing Corporation will develop an emergency housing relocation site program to identify flood-free housing sites in 14 highly floodprone southeastern counties.

- Minnesota Department of Natural Resources. To conduct a study of the effects of rising lake levels through a detailed investigation of 20 lakes in the state. The report will include a summary of the hydrologic history, degree of risk, and mitigation strategies for each lake.

- Indian Nations Council of Governments, Oklahoma. To begin the initial phase of establishing a coordinated multi-jurisdictional storm water/flooding plan, on a drainage basin approach. This project will cover the Tulsa metropolitan area which is subject to frequent severe flooding.

- Missouri State Emergency Management Agency: To: 1) Conduct a statewide levee policy conference; 2) prepare a hazard mitigation plan for the City of Hannibal; 3) prepare a handbook outlining the role of regional planning commissions in local mitigation; and 4) promote mitigation at workshops.

- Lewis and Clark Counties, Montana: To develop a multi-hazard mitigation plan for an 18 square mile rapid growth area located northeast of East Helena. Phase I will consist of a detailed hazard identification. Phase II will consist of planning through public participation.

- Nevada Division of Emergency Management: To prepare a state Hazard Mitigation Officer position description, appoint a person to fill that position, provide training for the HMO, prepare a hazard mitigation annex to the Nevada Emergency Operations Procedures, and prepare standard operating procedures for Section 406 planning.

- Alaska Division of Emergency Services: To develop and implement pilot flood mitigation plans for villages on the major river systems. The project will involve identification of up to 25 top priority communities, with an ultimate goal to develop mitigation plans for each community.

- **Flood Audits.** The SCS has worked closely with the State of Connecticut to provide both funding and technical assistance for a pilot project to conduct flood audits of structures located within the floodplain of the Yantic River in the City of Norwich, Connecticut. Under this program, individual structures are inspected to identify specific measures (both permanent and temporary emergency measures) that property owners may take to reduce their potential losses during a flood. The recommended actions are directly related to the projected height of flood waters during a one percent annual chance flood. The Corps and NWS have also provided assistance for this pilot project (von Wolffradt, 1986).

- **Comprehensive Flood Damage Reduction Studies.** At the request of a local sponsor, the Corps will conduct technical evaluations to determine appropriate floodplain management measures for a particular area. In recent years these planning studies have included recommendations for flood warning systems and other disaster preparedness measures. In addition, the Corps can provide technical analyses and planning assistance to local sponsors for comprehensive flood warning/preparedness studies under the Flood Plain Management Services program.

STATE AND LOCAL ACTIVITIES

Every state has an emergency management or disaster preparedness agency that is responsible for preparing for flood and other disasters. Each state on the Gulf and Atlantic coasts now has a hurricane preparedness plan either completed or under preparation through the Hurricane Preparedness Program described previously. Under the FEMA IEMS program, each state also has developed an integrated emergency management plan.

Many local governments also have emergency management plans prepared in accordance with the IEMS guidance. However, only a relative few local communities have detailed preparedness plans that deal specifically with floods. Some states, such as Florida, North Carolina, and California, have established requirements for county or municipal governments to develop emergency preparedness plans as part of their comprehensive land-use plans.

In 1984, New Jersey noted that it had only recently recognized predisaster planning as a separate work element (Gilman, 1984), and that such recognition was primarily the result of New Jersey's involvement in the Coastal Storm Planning and Preparedness Program. Although initiated for coastal communities, the concept of predisaster planning is being applied to inland communities as well. Eight specific methods for reducing flood losses through predisaster planning were identified:

- update municipal Emergency Operations Plans;
- review and develop detailed standards for construction;
- develop a standard operating procedure to alert residents of vulnerable areas;
- develop plans for removal of contents from vulnerable structures, where feasible;

- conduct surveys of existing structures to identify those that require retrofitting to provide adequate anchorage;
- identify inadequate protective structures and establish adequate setbacks;
- improve planning for traditional flood fighting techniques;
- purchase flood insurance.

"The Division of Coastal Resources is pursuing predisaster planning on an individual basis with municipalities and has found interest and support from those towns, along with a desire to utilize the state's technical expertise" (Ehinger, 1984). Transfer of Development Rights (TDR) was one concept being evaluated in Upper Township, NJ as a means of designating a high hazard section of the Township as a conservation/recreation zone and permitting higher density development in mainland portions of the Township.

EFFECTIVENESS OF DISASTER PREPAREDNESS ACTIVITIES

Participants during a 1988 workshop on postflood response and recovery addressed the need for and advantages of disaster preparedness plans. They were aware of only a few examples of plans prepared before a flood disaster that were designed specifically to deal with mitigation actions after a flood. Examples cited were Nags Head, North Carolina; Tulsa, Oklahoma; and Boulder, Colorado. It was noted that these examples really represented planning in response to one or more floods and in anticipation of the next flood. Many reasons were suggested for the absence of more of these types of plans, including: lack of local expertise and funding to develop plans, the short-sighted approach of many local elected officials, the hope that the flood problem would be taken care of through some structural measure, and the expectation of federal disaster assistance in the event a flood does occur.

Participants noted several instances where plans that had been prepared at some point in the past — often as part of a Corps project feasibility study — were pulled off the shelf after a flood, and recommendations from the plan implemented. These examples prompted the observation that "predisaster planning works even if plans don't exist; think what success we could have if they did exist."

The importance of a postdisaster planning process as opposed to a postdisaster plan with site-specific recommendations was discussed by workshop participants. The Nags Head, North Carolina plan was cited as providing a planning process that would be applied to specific sites depending on the severity of damage that occurred during a flood. The flood — not the plan — would determine the specific sites to which the planning process would apply. This approach was seen as having many benefits, especially avoiding the problems posed by trying to identify particular properties for demolition or other postflood restrictive actions, and thereby raising the ire of property owners (Association of State Floodplain Managers, Workshop #4, 1988.)

Several organizations and agencies (ASFPM, Bureau of Reclamation, and National Review Committee, among others) also have noted that preparedness plans are not used as much as some other floodplain management tools and that they deserve greater attention as viable damage reduction measures. The ASFPM (Larson, 1989) noted that areas below dams and behind levees were in particular need of preparedness and response plans. Research on the techniques, benefits, and costs of preparedness plans to identify their utility and impediments to their implementation has been recommended (National Review Committee, 1989). Better coordination between different agencies at the state level to prepare disaster preparedness plans, as well as more information and education regarding the need for disaster preparedness, have also been cited as essential items if preparedness planning is to become more effective (Fuller, 1989).

In comparing the results of a 1985 study of local emergency management agencies with studies in 1969 and 1977, a researcher noted that although disaster response activities have remained very similar, planning activities are more systematic and realistic. At the same time, " ... the quality of planning, while better than in the past ... still leaves much to be desired ... Most local emergency management agencies actually engage less in planning than in the production of disaster plans... The tendency to emphasize an end product, by way of a written plan, works against good disaster planning, but this is nonetheless the prevailing activity." By comparison with the earlier studies, communities are generally better prepared for nonwar emergencies (Quarantelli, 1985).

Another author noted that there has been no systematic study of preparedness plans, their implementation during flood emergencies, or flood detection and warning systems. It is therefore assumed that: 1) a disproportionate amount of the effort and funding in communities with flood warning systems has gone toward flood detection; 2) preparedness plans are nonexistent or inadequate in many of those communities; and 3) where there are both flood detection systems and preparedness plans, the plans are frequently unrealistic. These shortcomings are attributed to 1) lack of understanding at the community level of the value of preparedness planning; and 2) lack of federal interest and leadership in flood preparedness planning (Owen, 1986).

FLOOD FORECASTING / WARNING / EMERGENCY PLANS

Flood forecasting and flood warning and emergency plans are described together because in the context of flood emergencies, they must work together. Forecasting, warning and emergency plans are also closely linked with preparedness planning. The first element of response to an emergency is identification of the threat. The final element of an effective flood warning system is appropriate response to the warning, which requires preparedness planning (Owen, 1980a).

As in other areas of flood loss reduction, there is activity and interest in flood warning and preparedness planning among federal, state and local governments and the private sector. Federal and state agencies generally lack local operating capability needed for these activities, and most communities do not have the financial and technical ability to operate alone (Owen, 1980b). Although the theories and systems can be applied to a wide range of flood threats, they have generally been limited to riverine flooding (Owen, 1980a) and to flood threats from hurricanes.

In riverine flooding, the opportunities for effective flood warning and response depend on the nature of the flood threat. Flood forecasting procedures rely on real-time[11] hydrologic and meteorologic

[11] Real-time data refers to data that are accessible to a user immediately or almost immediately (perhaps a few minutes) after an event occurs.

data. These data are analyzed and transferred to downstream points by various methods, some simple, some quite complex. In the more sophisticated procedures, estimates of future meteorologic data are added to real-time data to improve the forecast. In a large river basin, upstream flows in the river and its tributaries may produce a very accurate forecast of downstream flooding, with many hours or even days to prepare for the flood. In upstream areas, where the watersheds are small, and especially if the watershed area is steep, the time between the causative event (generally rainfall) and the onset of flooding is only a few hours or minutes. Obviously, the preparedness opportunities are reduced as the warning time is reduced, but the need for preparedness is increased.

Flood warning systems are not static. They must be modified over time as more is learned about the hydrology, as warning needs change, and as the technology changes. There may be drastic changes required as the result of a cataclysmic event such as a dam failure or a volcanic eruption (Pasteris, 1987). Similarly, as institutional changes occur, the local response plan must be updated.

Flood warning and emergency response have long been recognized as effective ways to reduce flood damages and save lives.

In one documented example, annual damage reductions of $750,000 were estimated for the Connecticut River Basin with a flood warning system with an estimated annual cost of $250,000 (Day, 1976). A later study estimated a 20:1 ratio of benefits over costs for a state-wide warning system for Connecticut (Committee on Automated Flood Warning, 1988). It should be noted, however, that these estimates did not conform to standard benefit/cost calculations required of federal projects.

These types of large benefits have been observed in a few instances. In Manitoba, contents damages were only 6.3% of the total damages incurred during a 1979 flood. The low proportion of contents damages is largely credited to flood warning (Shawcross, 1987) and a long lead time (up to three weeks) (Myers, 1989).

Emergency preparedness planning often has been given a relatively low priority among both structural and nonstructural flood loss reduction measures, perhaps because many floodprone areas did not have adequate flood warnings to make preparedness planning effective. A 1982 publication notes that " ... [plans] should not be considered in lieu of other feasible permanent structural or nonstructural alternatives due to their temporary nature and uncertain reliability during flood episodes" (U.S. Army Corps of Engineers, 1982). Four reasons have been given for the lack of attention to preparedness plans:

1) Lack of precedents, examples, or similar experiences that can easily be transferred to preparedness planning;

2) Lack of awareness of the potential benefits;

3) Lack of federal interest and leadership; and

4) Lack of an appreciation of preparedness planning as a necessary adjunct to flood warnings (Owen, 1986).

FEDERAL ACTIVITIES

Several federal agencies are actively involved in flood forecasting, warnings and emergency plans. NOAA has lead responsibility for flood forecasting and initial distribution of warnings. FEMA has primary responsibility for working with local communities to ensure warning dissemination.

National Oceanic and Atmospheric Administration

NOAA has the lead role among the federal agencies with regard to flood forecasting and warning. Through its Office of Ocean and Coastal Resources Management (OCRM), the NWS, the National Ocean Service (NOS), the National Hurricane Center (NHC), and the Environmental Research Laboratories (ERL), NOAA issues warnings for floods and conducts research. In addition, the National Environmental Satellite Data and Information Service (NESDIS) operates the Geostationary Operational Environmental Satellites (GOES) which generate and relay meteorologic and other environmental data that are used in forecasts.

- **Riverine flood forecasts and warnings.** As the federal agency with primary responsibility for flood warning in the United States, the NWS provides specific flood forecast and warning services to over 3,100 communities. The NWS also works with many of the approximately 900 communities with some form of local flood warning system. Other communities (over 21,000 identified by FEMA as floodprone) receive warnings only through general county-wide flash flood warnings. Because of the large number of small, flash flood streams in these communities, the NWS is unable to collect and analyze data and disseminate effective warnings in these situations (National Weather Service, 1986). Local flood warning systems are not necessarily needed or even desired in all of the 17,000 or so communities that do not currently receive a direct flood warning.

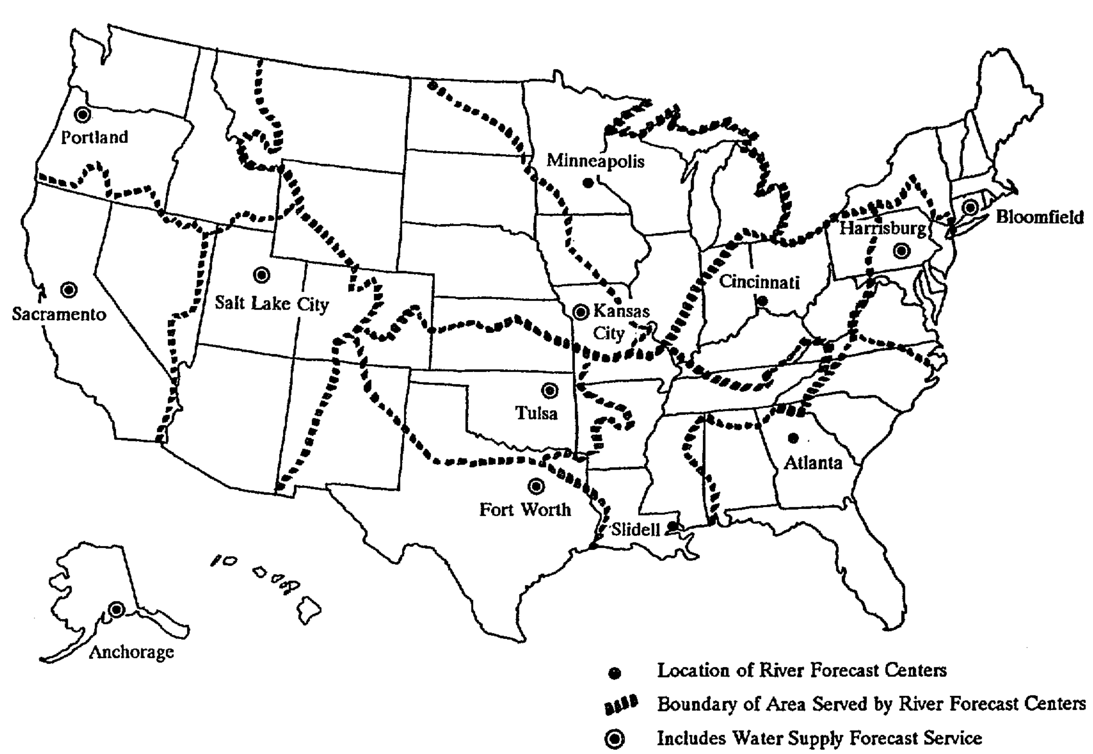
In the State of Connecticut, it is estimated that an integrated network of about 30 local flood warning systems will provide warning for most of the state (Committee on Automated Flood Warning, 1988).

The NWS operates 13 regional River Forecast Centers (RFC) which prepare river and flood forecasts and warnings for approximately 3,000 communities. The area of responsibility for each of these RFC's includes one or more major river systems. Figure 11-3 shows the location of the RFCs and Figure 11-4 graphically shows how information from several sources contribute to forecasts and warnings. Flood forecasts include the height of the flood crest, the time(s) when the river is expected to overflow its banks (reach flood stage), and when the river will recede within its banks.

Crest forecasts can be made a few hours in advance for communities on rivers draining small areas, but can be two or more weeks in advance for downstream sites on large rivers. At many points, particularly along larger streams, daily forecasts of river stage and/or discharge are routinely prepared. Reservoir inflow forecasts aid federal, state and local agencies in the operation of reservoirs. Forecasts of ice formation and breakup are prepared for a selected number of locations. Forecasts of seasonal snowmelt or water-year runoff are prepared monthly from January through May by RFCs in the west, and forecasts of seasonal snowmelt and monthly runoff are prepared monthly by RFCs in the northeast (National Weather Service, 1985).

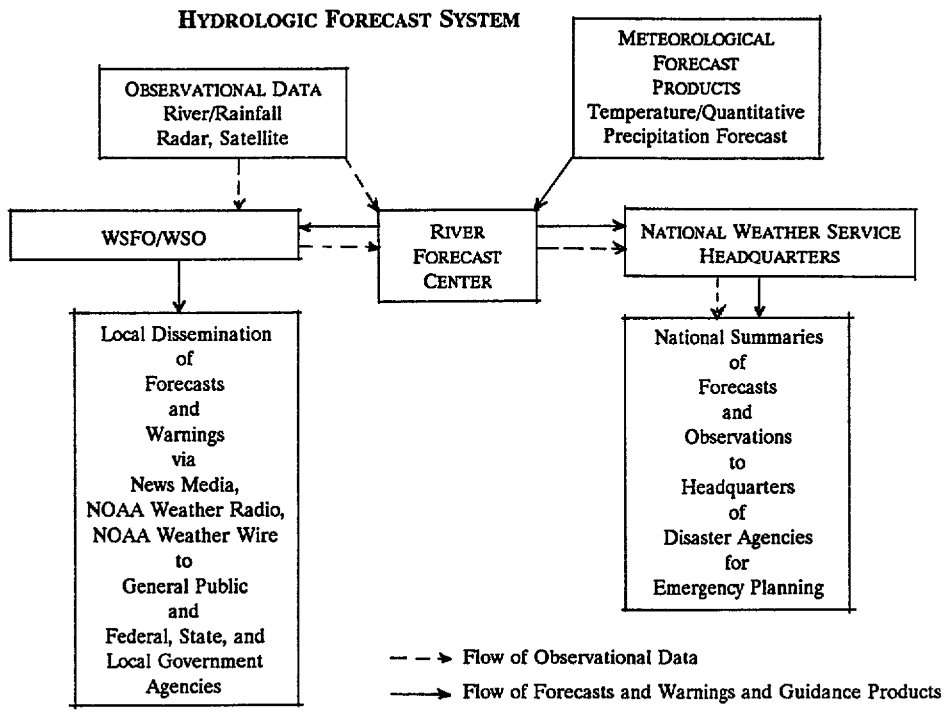
The potential for local flood warning systems is very large, and the number of operational systems is growing rapidly. A new NWS radar system, NEXRAD, that can provide more quantitative observations of precipitation should lead to improved flood warnings and more timely decision-making capability in the operation of flood control structures. Recent technology provides real-time snow-water equivalents and soil moisture measurements. The NWS Airborne Gamma Radiation Snow Survey Program uses the attenuation of natural terrestrial radiation by soil moisture and snowpack to make these estimates, which are better, in many cases, than ground measurements. These data are used for flood forecasts and other services (Carroll, 1986).

- LOCAL FLOOD WARNING SYSTEMS: Local flood warning systems (LFWS) are categorized as either manual or automated. A manual system usually consists of volunteer observers who relay data by telephone to a community flood coordinator. This person uses some kind of simple procedure, usually provided by the NWS, to convert the data to a river stage forecast. After consultation with NWS staff, the coordinator notifies the local response agencies. Automatic systems consist of an automated data collection system, communications, data processing, and warning dissemination system. An automated LFWS may be as simple as an upstream river stage gage which sounds an alarm downstream at some predetermined stage, or complex enough to include satellite telemetry, sophisticated hydrologic modelling and detailed response plans.



Source: National Weather Service. Operations of the National Weather Service. Silver Spring, Maryland, 1985.

Figure 11-3. Location of National Weather Service River Forecast Centers.



Source: National Weather Service. Operations of the National Weather Service. Silver Spring, Maryland, 1985.

Figure 11-4. National Weather Service Hydrologic Forecast System.

In 1985, about 540 manual LFWSs were in operation with NWS coordination. These systems are simple, inexpensive and encourage a high level of community awareness and participation, but they are prone to communication failures and unreliable data.

Automated LFWSs which are operational are of two basic types. The Automated Local Evaluation in Real Time (ALERT) system developed by the NWS consists of automatic reporting rain and stream gages, radio telemetry and computer analysis of the data. This analysis may include hydrologic modeling. The Integrated Flood Observing and Warning System (IFLOWS) is a network of automated systems which uses federal, state and local resources to provide detailed flood warnings to a large region with numerous political jurisdictions (Barrett, 1986).

The NWS inventory of local flood warning systems lists over 1,200 such systems in 42 states and Puerto Rico as of January 1, 1987 (National Weather Service, 1987). This figure is only of relative significance, however, since it appears (at least in some cases) to inventory individual precipitation and streamflow gages instead of complete integrated systems. Further, a single gage reporting to a single downstream point is counted the same as a complex data collection and analysis system which provides forecasts at a number of locations.

Although the NWS had the lead role in developing ALERT systems, in cooperation with private interests, resource limitations have resulted in a reduced role for the NWS and an expanded role for private vendors who work directly with states and communities.

- **Coastal Flood Forecasts and Warnings.** Among NOAA's efforts to reduce hurricane losses are: 1) research on hurricane surge models; 2) assistance to states and communities in evacuation planning; 3) research on storm modification through seeding; and 4) tracking and forecasting the path, speed and intensity of tropical storms and hurricanes.

- **Hurricane Preparedness Program.** As discussed in the Disaster Preparedness section of this chapter, NOAA cooperates with FEMA and the Corps to prepare Hurricane Preparedness Plans for Gulf and Atlantic coast states. One of the first elements of a Hurricane Preparedness Study is performance of a Hurricane Hazard Analysis. Analysis results form the basis for determining vulnerable areas that require evacuation. The principle tool used in the hazard analysis is the NWS SLOSH (Sea, Lake and Overland Surges from Hurricanes) model. SLOSH is used to generate a series of simulations of possible hurricanes within a specific area or basin. Figure 11-5 shows the location of SLOSH basins along the Gulf of Mexico and Atlantic coastlines. Normally, the five storm intensities of the Saffir/Simpson scale are simulated. Three hundred or more simulation runs may be performed, representing various combinations of hurricane intensity, track, size, and forward speed.

  Each hypothetical hurricane simulated by SLOSH would confront an area with one of many distinct hazard scenarios which, in turn, ultimately make up the evacuation scenarios, or levels. The output of the SLOSH model provides four major types of information on the effects of the simulated hurricanes. They are: 1) surface envelope of highest surges above mean sea level; 2) time histories of surges at selected gages or grid points; 3) computed wind speeds at selected gages or grid points; and 4) computed wind directions at selected gages or grid points. The results of individual surge model simulations (and/or groups of common intensity/track types, termed Maximum Envelopes of Water—MEOWs) provide predicted storm surge elevations. Inundation maps based on these predicted storm surge elevations indicate vulnerable coastal areas and form the basis for several distinct evacuation levels (L.R. Johnston Associates, 1986).

- **Forecasts and Warnings for Hurricanes and Tropical storms.** The National Hurricane Center in Coral Gables, Florida issues all forecasts and storm warnings for hurricanes, including storm surge forecasts generated by the SLOSH model. A separate wave height forecast is not prepared for hurricanes since the SLOSH model indirectly incorporates waves into its storm surge prediction. NWS Regional Weather Service Forecast Offices (WSFO) and local Weather Service Offices (WSO) do not modify the NHC forecasts and warnings, although they may supplement them with up-to-date reports on local conditions, including wave heights, and provide additional warnings for particular geographic areas. Local weather conditions are provided to the NHC over a Hurricane Hotline by NWS offices in the affected areas, and used by the NHC in developing its hurricane forecast. Hurricane forecasts are updated by the NHC every six hours. When Hurricane Watches or Warnings[12] are not in effect, Public Advisories based on these forecasts are issued. Once the NHC issues a Watch or Warning for a particular area, Public Advisories are issued every three hours. Similar procedures are followed by the NHC in preparing forecasts and warnings for tropical storms (L.R. Johnston Associates, 1986).

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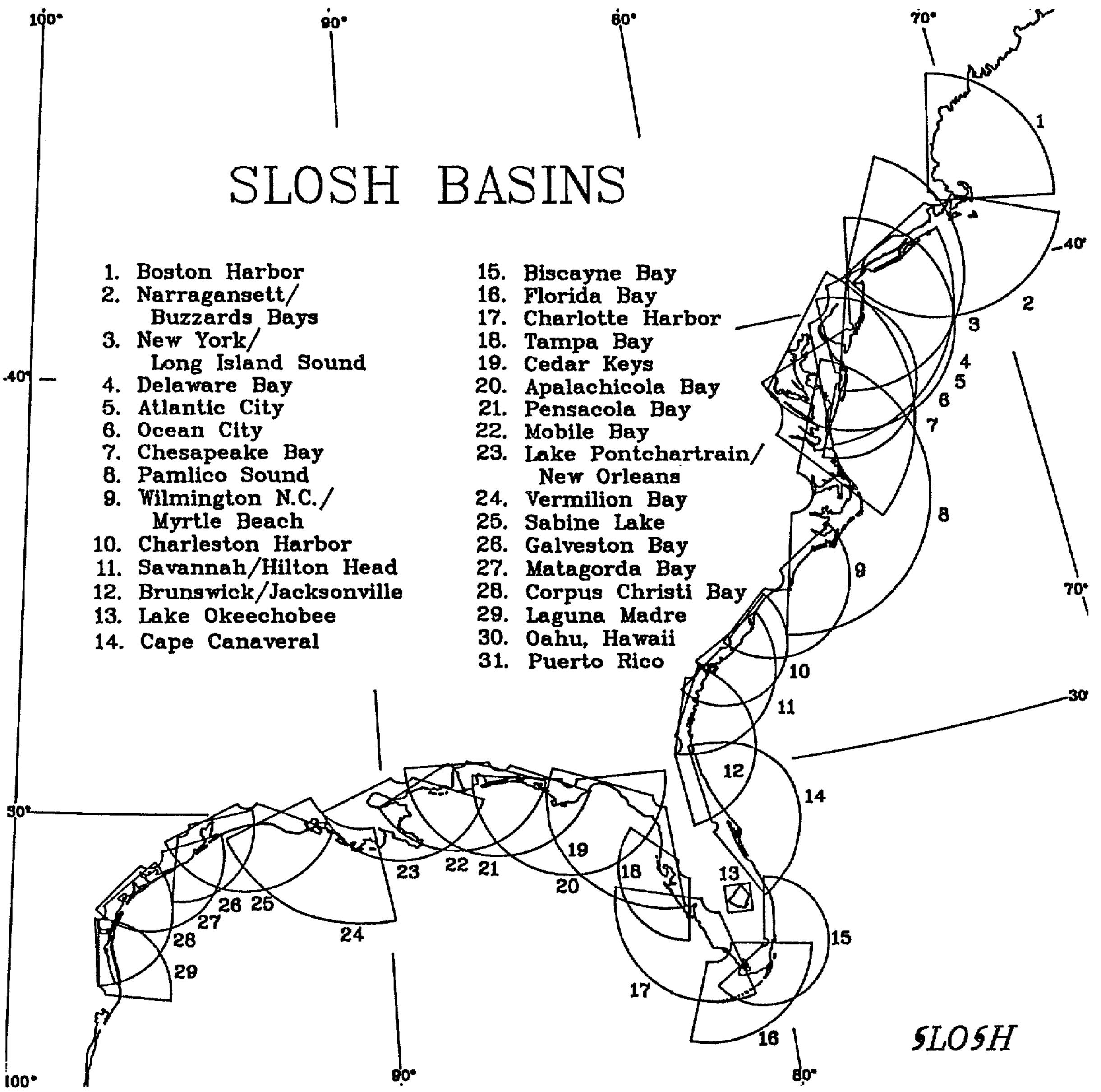
[12] A Hurricane Watch is issued for a coastal area when there is a threat of hurricane conditions within 24-36 hours. A Hurricane Warning is issued when hurricane conditions are expected in a specified coastal area in 24 hours or less (Carter, 1983).



Source: Jelesnianski, C.P., J. Chen, W.A. Shaffer, and A.J. Gilad. "Slosh — A Hurricane Storm Surge Forecast Model." Silver Spring, Maryland: Techniques Development Laboratory, National Weather Service, NOAA, Undated.

Figure 11-5. SLOSH Basins Along the Gulf of Mexico and Atlantic Coastlines.

Beginning with the 1983 hurricane season, the NHC began including in the Advisory the probability of the hurricane reaching landfall at specific locations. Probabilities are defined as the percent chance that the center of the storm will pass within approximately 65 miles of a stated location (Carter, 1983).

Other Federal Agencies

The Corps, TVA, and the Bureau of Reclamation (BOR) collect hydrometeorological data and prepare operational forecasts, frequently in cooperation with the NWS, for their multi-purpose (e.g., flood control, water supply, and navigation) structures. The NWS generally provides warnings from all of these sources to the public. The U.S. Geological Survey (USGS) collects streamflow and other data that can be used for flood forecasting.

The Corps provides comprehensive flood warning and preparedness planning assistance to states and communities under its Flood Plain Management Services Program. The Corps also develops flood warning and preparedness plans as either stand-alone systems or as components to more complex flood damage reduction plans for communities.

The Soil Conservation Service (SCS) and the NWS cooperate with numerous federal, state and local agencies to produce generally volumetric runoff forecasts for western areas where snow is a major contributor to annual water supplies. It has been suggested that data used for these analyses can be interpreted to give long-term quantitative peak flow estimates for spring runoff. Real-time data from snowcourses can also be used in conjunction with other real-time data to improve more immediate forecasts (Potyondy, 1987).

Several of these federal agencies also operate research facilities that contribute heavily to the body of knowledge about flood forecasting and response, and all of them have worked with states and communities on different aspects of flood warning and preparedness planning.

STATE AND LOCAL ACTIVITIES

In general, the states have not assumed a major role in flood warning or even defined what role they should have. Less than half of the states are involved in flood warning, which includes cooperation in the IFLOWS system in Appalachia and installing automated data collection equipment. A comprehensive study by the State of Connecticut recommended about 30 ALERT-type systems coordinated on a statewide basis, citing 40,000 floodprone buildings in the state despite the expenditure of over $315 million on structural flood control measures. The state estimated that a system that would cost $2 million to install over a 15-year period would reduce loss of life in floods by 75% and produce average annual damage reduction of $5 million. Implementation is underway (Committee on Automated Flood Warning, 1988). Table 11-11 lists state involvement in flood warning activities as of 1988 (Association of State Floodplain Managers, 1988).

Table 11-11. State Flood Warning Activities.

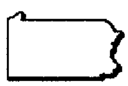
FUNDING	DATA COLLECTION	STATE-OPERATED SYSTEM	ASSIST LOCALS INFORMATION	ASSIST LOCALS FUNDING
Alaska				
Alaska	X	1	X	X
Arizona	X	X	X	X
Arkansas				
California	X	X	X	X
Colorado	X	X	X	
Connecticut	X	X	X	X
Delaware	X	X	X	
District of Columbia				
Florida	X	X		
Georgia				
Hawaii	X	X		
Idaho				
Illinois				
Indiana	X		X	X
Iowa				
Kansas				X
Kentucky			X	
Louisiana				
Maine				
Maryland	X	X	X	X
Massachusetts				XX
Michigan	X	X	X	
Minnesota	X		X	X
Mississippi				
Missouri				X
Montana				
Nebraska	X			
Nevada				
New Hampshire	X	X		
New Jersey	X	X	X	X
New Mexico	X	X		
New York	X		X	
North Carolina	X	X	X	X
North Dakota				
Ohio				X
Oklahoma				X
Oregon				
Pennsylvania	X	X	X	X
Rhode Island				
South Carolina	X		X	
South Dakota	X	X	X	
Tennessee				X
Texas				XX
Utah	X	X	X	X
Vermont				
Virginia				
Washington				XX
West Virginia	X	X	X	
Wisconsin			X	
Wyoming				X

1 Alaska operates a tsunami warning system.

Source: Association of State Floodplain Managers. "State Floodplain Management Programs. Results of a Survey Conducted by the Association of State Floodplain Managers for L.R. Johnston Associates," 1988.

As with the states, there is no consistent flood warning policy among the nation's communities. Some large urban communities have included flood forecasting and preparedness planning in their operations for years. Other communities have participated in flood warning systems that serve a large geographic area with many communities affected. Others have developed systems on their own. It is likely that communities with local flood warning systems are those that have been flooded and which have the financial resources to do so. The result is that some of the areas that might benefit most from an expenditure in flood warning do not have it, while wealthier, but less flood-prone communities do.

Local governments are involved in nearly all local flood warning systems reported by the NWS. The NWS *Operations Manual* states in its General Policy, "Recognizing the importance of LFWS's in improving flood warning service to communities, the NWS will continue to provide technical assistance to communities to the extent resources are available ... The basic NWS philosophy behind an LFWS is that it is a cooperative venture between the Federal Government and a cooperator with a need for a flood warning system ... Communities are usually in the best position to understand their local flood problems, to observe events during flood periods, and to take appropriate actions to limit flood losses ... In general, the cooperator is expected to procure, install, maintain and operate all LFWS equipment necessary to meet its requirements ..." (National Weather Service, 1986).



Lycoming County, Pennsylvania lies almost entirely within the drainage area of the West Branch of the Susquehanna River and contains close to 2,200 miles of streams. The majority of the county's population is located on or near the river. Although annual flooding on many of the waterways was common, major flooding caused by tropical storm Agnes in 1972 ($54 million in damages) and tropical storm Eloise in 1975 ($9 million in damages) provided the stimulus for an integrated system of floodplain management, which includes floodplain land-use management, an early flood warning system, and public and private emergency preparedness.

Development of the warning component dated back to the flooding from Agnes when forecasting and warning were inadequate due to several reasons — among them, damage to river gauges during the flooding, incomplete radar coverage, and lack of formal warning procedures. After the second major flooding three years later with Eloise, a self-help flood early warning system was developed in 1976 with an initial investment of $500. With the help of the National Weather Service, forecasting procedures were established for each county watershed, and the system was put into operation within three months.

Volunteer observers (over 100) were recruited and trained to observe and monitor stream gauges and make reports to a stream coordinator. The stream coordinator, in turn, assembles the data for a watershed and conveys it to a system coordinator. With the help of expert personnel, the data are evaluated and a determination of expected flooding and appropriate response measures is made.

Over the last 10 years, improvements to the system have been made. To assure adequate back-up for data transmission, the county provided NOAA weather radios to the volunteer observers, and the NWS distributed base station radios to the stream coordinators. In addition, a system of 10 automated rain gauges and four automated stream alarm devices were installed to supplement the manual data collection system (Hunter, 1986).

Examples of communities which have installed automated LFWSs on their own include Denver, Colorado (Stewart, 1987); Maricopa County, Arizona; Stamford, Connecticut; Westchester County, New York; and Harris County, Texas. A plan for an improved flood warning system has been designed for the Passaic River Basin in New Jersey.

The Passaic River Watershed is a 935-square mile, highly populated area located in the states of New York and New Jersey with severe unsolved flood problems. The Passaic River Basin, with a population of over 2 million (1980 est.), includes many levels of political jurisdiction (portions of two states, 10 counties and 132 municipalities). The flooding problem has been extensively studied by both state and federal interests since 1900. Estimated annual flood damages were estimated at over $80 million (in 1985 dollars).

An early warning system had been recommended as part of a Corps feasibility study on the Passaic River Basin authorized by Congress in 1976. Severe flooding in April 1984, causing over $350 million in damages and four deaths — despite an existing flood warning system — provided the impetus to implementation of an improved warning system.

The plan for an improved flood warning system, with an estimated cost of $675,000, was recommended for implementation under the Corps Small Project Authority, rather than as part of a comprehensive project authorized by Congress. It was designed to extend the coverage of the existing system and to reduce the time necessary for forecast preparation and warning systems. Elements of the plan included:

- automated reporting of data in six tributary areas where response time was exceeded by forecast preparation time;
- automation of all precipitation and stream gages to avoid observer bias and to speed delivery of data;
- transmission of radio signals from the gages to county micro-computer sites and automatic dialing to remote terminals at municipal emergency headquarters;
- preparation of stage-inundation maps;
- updating and coordination of county/municipal response plans; and
- periodic flood response exercises and public education.

A major issue raised by the proposed project was the degree to which the Corps should be involved in planning and implementation of the project and the long-range impact of establishing a precedent for Corps flood emergency preparedness projects across the Nation. The 1976 Congressional authorization for the Passaic River Basin Study had specifically directed the Corps to consider early flood warning systems along with other nonstructural measures. However, the final project was to be implemented as a discreet project under Corps' continuing small project authorities, rather than as part of a comprehensive construction project authorized by Congress. The argument was also made that the project should be authorized by Congress for implementation by agencies involved in the existing warning system (NWS, FEMA and USGS). However, the other federal agencies supported the Corps recommendation and played major roles in the development of project specifications. The final project study was completed by the New York District of the Corps in September 1984 and the Local Cooperation agreement was signed in October 1986 (Pietrowsky, 1986).

Local governments have apparently accepted a responsibility for preparedness planning, perhaps because of a history of civil defense and emergency management funding by the federal government. The NWS policy on local flood warning systems strongly encourages the cooperator in such a system (generally the local government) to develop an emergency action plan prior to development of the data collection and analysis system, but no standards for these plans are given (National Weather Service, 1986). It has also been noted that this NWS policy does not appear to have been consistently enforced (Owen, 1989).

At the local level, the agency usually designated as the emergency response agency actually spends most of its time in planning and preparedness. This is because in even the most disaster-prone communities, disasters are relatively infrequent and generally of relatively short duration. This planning ranges from a total civil defense (mainly nuclear war) orientation to integrated emergency preparedness planning which prepares the agency and the community for a wide range of emergencies.

Local emergency management agencies are generally active in the warning process, although they are seldom the first agency to become aware of the threat. They have taken on the role of monitoring emergencies and disseminating information to other agencies and to the public, although there are usually problems related to a lack of good information during emergencies (Quarantelli, 1985).

PRIVATE SECTOR ACTIVITIES

University research has contributed substantially to the available knowledge on data collection requirements, hydrology, and benefits of flood warning systems. In addition, universities have performed most of the research on disaster response and system effectiveness. Much of this research was funded by the U.S. Water Resources Council, the National Science Foundation, and other federal sources, but the Nation's universities provide a large pool of expertise to use these funds effectively.

Nonprofit organizations are less active in this area because they generally deal with disaster response or recovery. They frequently provide input to planning agencies based on their experience with flood disasters. While this experience may be of great assistance to the planners, it is generally a small part of the activities of the nonprofit agencies.

Special districts and utility companies include flood control districts, stormwater management districts, drainage districts, irrigation districts, nature conservancy districts, electric utilities which operate hydroelectric facilities, private fire companies, and similar organizations. They are usually financed by taxes and regulated by federal, state or local agencies. Because they usually have narrowly defined objectives (relative to government as a whole), they frequently have technical capabilities and expertise disproportionate to their size and budget. When their objective is related to water, or is unusually affected by water, much of this capability or expertise is often applicable to flood warning and disaster preparedness. In the case of flood control and stormwater management districts, these districts may be so closely related to local government that they are in fact the action agency for flood warning or preparedness planning.

The development of technology for data collection, telemetry, and analysis has been largely accomplished in the private sector. The application of these new technologies has been accomplished through the NWS in large measure, but private funds have been used for most of the research and development. Due to a limited number of flood warning professionals in the Nation, the private sector has an extremely important role in the implementation of local flood warning systems, from design through installation, operation, maintenance, and modification (Curtis, 1986).

Finally, there are instances where industry has cooperated for the implementation of flood warning systems to reduce its own losses. These efforts are coordinated with government activities and may supplement public efforts, including funding (Wright, 1986).

EFFECTIVENESS OF WARNING AND RESPONSE SYSTEMS

Activity and interest in flood warning and preparedness planning among federal, state and local governments and the private sector has increased significantly over the last ten years. Among the reasons for the increased interest are: the advantages of low cost, high benefit/cost ratio, no environmental impact, little controversy, quick planning and implementation, and an almost unique ability to cope with catastrophic levels of flooding (Owen, 1989).

Automated systems have been developed that are gradually taking the place of manual warning systems or being used in locations where no warning system was previously in place. Although the theories and systems can be applied to a wide range of flood threats, they have generally been limited to riverine flooding and to flood threats from hurricanes.

In an overview of the technological aspects of automated flood warning systems during a 1988 workshop, it was pointed out that the systems are highly integrated and a breakdown in any part of the system can render the system inoperable (Association of State Floodplain Managers, Workshop #7, 1988). In fact, this breakdown has been observed in many locations throughout the country (Mendell, 1988).

The benefits of automated warning systems are reduced damages and saved lives, but these benefits have seldom been quantified and related to system costs. There are few evaluations of flood warning systems in the literature, and no "before and after" studies of effectiveness. Because of political decisions to install systems, there is little incentive for local communities to conduct and publicize this type of information, except where the systems have clearly been successful. In a recent study of 18 warning systems, nine had not yet had experience with flooding. In the systems that had experienced flooding, seven worked acceptably, while two had problems (Association of State Floodplain Managers, Workshop #7, 1988).

Performance of warning systems can be measured in terms of warning time provided relative to warning time needed to take effective action, the dollar savings in property removed from the floodplain or otherwise protected, and lives lost. Another — often overlooked — benefit and measure of performance is prevention of unnecessary warnings and evacuations. Cost savings of not deploying emergency services or causing businesses to close can be substantial. Research has discounted the "cry wolf" syndrome as a myth with regard to flood warnings, and has shown that individuals are willing to accept a limited number of false warnings without loosing confidence in the system or failing to take action. Installation of an automated flood warning system can be a means for local officials to appear to have taken effective action, even if the system is not properly designed or maintained. Many automated systems were installed primarily to save lives from flash floods, and it can be almost impossible to establish a useful benefit/cost ratio for these systems (Mulady, 1988).

A response system used in concert with the local forecast/warning system is essential. Absence of an effective response system would greatly reduce the usefulness of a sophisticated automated warning system (Mulady, 1988), and there would be a strong likelihood of taking inappropriate action in response to a warning. "Flood warning and preparedness planning may be discussed separately for purposes of evaluation, but they must be linked together operationally if flood warning is to be effective" (Owen and Wendell, 1981).

Although the NWS and some other agencies do some work on flood warning, tying the warnings to flood response plans has been left up to the warning recipient. Lack of sufficient NWS funds and staff to assist in implementing local flood warning systems and flood preparedness planning has limited development and maintenance of these systems (Wetmore, 1989).

Federal and state agencies generally lack the local operating capability needed for these activities, and most communities do not have the financial and technical ability to operate alone. With the exception of the Hurricane Preparedness Planning effort, it is unusual for state or local governments to fund an adequate flood warning system and emergency plan until there is a major flood. In some cases, funding is lacking even following major floods in which it is clear that millions of dollars in property damage and even loss of life could have been avoided. State and local governments are sometimes unwilling to establish and maintain such systems and plans. Finding ways to strongly encourage the establishment of such systems is a challenge facing the floodplain management community (Federal Emergency Management Agency, 1989).

FLOODPROOFING AND ELEVATION

Floodproofing refers to the use of techniques to either prevent entry of flood waters into buildings (dry floodproofing) or to minimize the damages from water[13] that is deliberately allowed to enter a building (wet floodproofing). Floodproofing may be applied both to construction of new buildings and to existing structures (retrofitting) located within floodplains.

Some of the floodproofing techniques that may be employed include:[14] use of permanent or temporary seals; closures or barriers to prevent floodwater from entering a building; use of water

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13 Water may sometimes be deliberately introduced into wet floodproofed structures in order to equalize the hydrostatic pressure inside and outside the building.

14 Elevation of a structure above a specified flood level is sometimes cited as a "floodproofing" technique. However, the NFIP makes a clear distinction between elevating structures and floodproofing them. Similarly, use of small levees or floodwalls to protect individual structures or a small group of structures is considered by some as "floodproofing" rather than as a "structural" protection method.

resistent materials; and temporary relocation of contents of buildings to avoid contact with floodwater. These techniques may be used individually or in various combinations.

Floodproofing may also be defined in terms of the level of human intervention required:

- Permanent Measures: Those that become an integral part of the structure and are rarely noticeable. They also generally do not require any type of human intervention to be effective.
- Contingent or Standby Measures: Those that are used only during floods, but which are constructed or made ready prior to any flood threat. These measures require some human action to be effective.
- Emergency Measures: Those carried out during a flood according to a predetermined plan. These may require major efforts to be effective (Sheaffer, 1967).

Floodproofing in some form can be applied to almost any type of building: single- and multi-family residences; small commercial buildings; industrial facilities; public buildings; and public utilities.

Floodproofing as a means of reducing susceptibility to flood losses has long been employed in a limited manner by individual property owners. In fact, floodproofing is probably the flood loss reduction tool most widely used by the private sector with only limited governmental assistance. Prominent early examples of private floodproofing efforts include the Pittsburgh Press Building and Horne's Department Store in Pittsburgh, Pennsylvania which were floodproofed following major flooding in 1936 (Sheaffer, 1967).

Much of the private floodproofing effort has been accomplished using methods devised by individual property owners, without benefit of technical knowledge of the effectiveness of the chosen method to actually protect a structure from a given flood level. Consequently, much of the private effort is suspect in terms of its effectiveness. Application of tested floodproofing techniques is not nearly as widespread.

LIMITATIONS OF FLOODPROOFING

While floodproofing offers many advantages, and if properly used can significantly reduce flood losses, the risk of failure of floodproofing measures from a variety of causes is always a possibility. There are many limitations and issues concerning the use of floodproofing measures, including:

- Floodproofing may generate a false sense of security and encourage inappropriate occupancy of buildings during floods.
- If flood levels exceed the design standard for floodproofing measures, residual losses may be high.
- If applied to structurally unsound buildings, floodproofing can result in more damage than would occur without floodproofing, (e.g., if water pressure on the foundation or walls of a building become too great, the walls may collapse from hydrostatic pressure).

- Floodproofing is only partially effective unless it also provides safe access — especially for commercial buildings and critical facilities such as hospitals and police and fire stations.

- Floodproofing should avoid aggravating the effects of flood hazard on others.

The limited effectiveness of floodproofing techniques can be attributed to many causes, including: insufficient knowledge of flood risk (probability of flood waters reaching a given height), insufficient warning of the magnitude and extent of flooding; use of inappropriate techniques and materials; and failure to use available measures.

FEDERAL ACTIVITIES IN FLOODPROOFING

The TVA and the Corps were the first federal agencies to become actively involved in research and promotion of floodproofing. In the early 1960s the TVA conducted studies into the benefit/cost of floodproofing for several communities in Tennessee and Virginia. The TVA and the Corps jointly funded publication of *Introduction to Flood Proofing: An Outline of Principles and Methods*, the first comprehensive treatment of floodproofing as a technique for reducing flood losses (Sheaffer, 1967). This publication was based on earlier research by John Sheaffer at the University of Chicago (Sheaffer, 1960). These two documents were the first to carefully examine the technique of floodproofing, classify the different types of floodproofing that could be used, and provide guidance for the use of floodproofing.

Following a review of available information and evaluation of suitable techniques, the Corps in 1972 published *Flood-Proofing Regulations* (U.S. Army Corps of Engineers, 1972). This document was intended to provide specific floodproofing standards that could be used to supplement existing building codes, or to devise a separate floodproofing code. The major regional building codes, many state codes, and hundreds of local codes either incorporated these "Flood-Proofing Regulations" into their codes by reference or referred to them as guidelines that individuals were encouraged to follow.

Over the next few years additional research regarding floodproofing techniques and application continued, primarily at the federal level. The Corps continued to lead in this effort as field offices included floodproofing as an alternative flood loss reduction measure as part of feasibility studies for flood control projects. Most of the Corps' early efforts at floodproofing focused on existing structures.

In 1976, the Corps' Waterways Experiment Station published *Structural Integrity of Brick-Veneer Buildings* (Pace, 1976), documenting for the first time under laboratory conditions structural failures of brick-veneer walls at a depth of three feet of flooding. In 1977, the South Atlantic Division of the Corps published *Flood Proofing: Example of Raising a Private Residence* (McKeever, 1977). In the late 1970s, the Corps provided technical assistance to property owners for floodproofing several structures in Prairie du Chien, Wisconsin as part of a well known nonstructural flood control project.

In the mid-1970s the FIA also became involved in efforts to provide information on floodproofing. The FIA emphasis was on new construction, and the first of many FIA documents relating to floodproofing and construction of structures in floodprone areas were published in 1977: *Elevated Residential Structures: Reducing Flood Damage Through Building Design: A Guide Manual* (Federal Insurance Administration, 1977); and *Manual for the Construction of Residential Basements in Non-Coastal Flood Environs* (Federal Insurance Administration, 1978).

During the next ten years, these early documents were followed by a succession of additional and revised documents released by both the Corps and the FIA. Most of these publications were based on research into techniques for new construction and for retrofitting existing structures. For construction in coastal areas, the research and ensuing publications included techniques for protecting structures from the effects of high winds (including hurricane force winds), and from the effects of wave run-up and scour on foundations. Relatively little research and publication was devoted to temporary and emergency floodproofing measures.

After several years of researching floodproofing for residential properties, the Corps in 1985 established a National Flood Proofing Committee to promote the development and use of floodproofing techniques for all types of properties, provide a source of technical expertise on floodproofing techniques, and to disseminate floodproofing information. The activities of the Committee have included: a seminar on floodproofing in December 1987 as part of the seminar series of the Federal Interagency Floodplain Management Task Force, publication of *Systems and Materials to Protect Buildings from Floodwaters* (Waterways Experiment Station, 1988), and publication of a bibliography of floodproofing (National Flood Proofing Committee, 1988).

The Corps has been involved for several years with a project to reduce flood damages in the communities of Williamson and Matewan in West Virginia and South Williamson in Kentucky, all in the Tug Fork Valley. Major flooding in the Tug Fork Valley in 1977 destroyed about 600 homes and damaged another 6,000. Corps technical and financial assistance was authorized by Section 202 of P.L. 93-25. This Act specified that flood protection should be provided to the level of the 1977 flood, which was about a 0.2 percent annual chance ("500-year") flood.

The project involves several components, including floodproofing of about 270 homes. Cost-effectiveness criteria are being applied to determine which homes should be floodproofed. There is no floodproofing of manufactured homes or of any structures in the floodway (the floodway is being evacuated). Many homes are being elevated as much as 12 feet. Because of the magnitude of the project, the variety of size and construction styles of the homes being floodproofed, and the height to which some homes are being elevated, the Corps is carefully documenting the entire project and has prepared a technical manual for design of floodproofing/elevation techniques (Everman, 1987).

The Baltimore District of the Corps, at the request of the City of Baltimore, Maryland, has performed planning evaluations and made recommendations for floodproofing to several businesses and industries in the Jones Falls Valley portion of Baltimore (Baltimore District, Undated).

In addition to the specific projects described above, the Corps routinely evaluates the potential for floodproofing as part of all project feasibility studies. Through the Flood Plain Management Services Program, the Corps also provides technical assistance to local communities (Plott, 1987).

In the past, HUD has incorporated construction standards, including floodproofing requirements, into HUD minimum property standards. However, HUD is now relying more on local codes and ordinances and less on its own minimum property standards (Randall, 1987).

Floodproofing or elevating existing structures (retrofitting) to render them less susceptible to flood damages provides a major opportunity and challenge given the large number of buildings constructed in floodplains prior to community adoption of minimum floodplain regulations (referred to by FEMA as pre-FIRM structures). As of the end of 1986, FEMA estimated that 1,338,767 out of 1,972,034 (or 68%) of all flood insurance policies covered these pre-FIRM structures. FEMA has been considering several alternatives for encouraging or requiring greater retrofitting of pre-FIRM structures. Technical and financial assistance options being considered include: 1) provide FEMA technical assistance to assist with privately funded projects; 2) initiate a low interest loan program for retrofitting, using the provision of Section 1362(c) of the NFIA; 3) coordinate use of the substantial improvement clause to qualify flood-damaged buildings for Small Business Administration (SBA) loans; and 4) work with communities to help them obtain funding, such as HUD grants, for retrofitting.

Insurance options that the FIA has considered include: 1) reduction in insurance rates for retrofitted buildings; 2) waiver of the insurance deductible if the building is retrofitted; 3) allow claim payments to be used, along with other forms of funding, to permit retrofitting; 4) initiate a low interest loan program for insured buildings to be retrofitted, based on a calculated reduction in insurance loss expectancy; 5) recognition of a retrofitting program in the community rating system; 6) insurance rate surcharge for buildings that suffer repetitive losses; and 7) enactment of a co-payment penalty to claims payments for buildings that suffer repetitive losses if they are not retrofitted (Mahoney, 1987).

The federal government, through the Corps, TVA and FIA, clearly established the lead in both researching and promoting the use of floodproofing as a tool for reducing flood losses.

STATE AND LOCAL INVOLVEMENT IN FLOODPROOFING

There are a number of examples illustrating the provision of information and technical assistance by state governments, as well as examples of local governmental assistance for the floodproofing of individual structures.

State Activities

The predominant role of state governments during most of the last 20 years has been to distribute information about floodproofing and provide technical assistance to individuals or groups of property owners, often using information developed and published by the Corps and FIA. Several states have taken a more active role in assisting with and promoting the use of floodproofing.

Minnesota, in 1974, incorporated Corps floodproofing regulations in the state building code (applicable to all local governing bodies) (State of Minnesota, 1974) and developed an administrative manual (U.S. Army Corps of Engineers, 1977).

Perhaps the most ambitious state effort to directly promote and provide financial assistance for floodproofing was that undertaken by Massachusetts following the "Blizzard of '78." After this devastating coastal storm in February, 1978, the Commonwealth of Massachusetts established a program to provide technical assistance to owners of coastal residences. The state developed a guidebook (Disaster Recovery Team, 1979) to assist homeowners in: determining whether their residence was a candidate for floodproofing; identifying floodproofing techniques that might be used; working with a contractor who would actually do the work; and obtaining financial assistance. The effort was focused primarily on elevating structures and/or elevating utilities above the base flood level. Structures located within coastal high hazard areas (V-zones) were not recommended for floodproofing.

Funding of $1.78 million for the program was obtained through grants from HUD, using the Secretary's Discretionary Fund and the Community Development Block Grant Program. A total of 105 communities participated in the Massachusetts Coastal Floodproofing Program. Following completion of the initial program, the Disaster Recovery Team assisted in the development of and provided funding for floodproofing programs in the coastal communities of Revere and Hull, Massachusetts. Approximately 50 families received assistance for floodproofing their residences under this additional program, at a total program cost of approximately $470,000 (Domas, 1982).

In 1979, Illinois published the first of a series of manuals directed to homeowners that included information on floodproofing. In 1984, Illinois published a second manual that could be used by local governments or individuals to determine if a building was suitable for floodproofing. Since then Illinois has held floodproofing seminars addressed to both industry and residences, produced additional publications on floodproofing, provided technical assistance to individual property owners, provided information on floodproofing to disaster victims, and established a loan program for floodproofing structures following a flood.

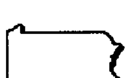
After floods in 1982, 1985, 1986 and 1987, Illinois provided technical assistance on floodproofing and other mitigation techniques to disaster victims who visited the local Disaster Application Centers. Follow-up surveys have been conducted to determine the extent to which residents took action, including floodproofing. A summary of the findings from these surveys indicated (Laska, 1988):

- Over half of the flood victims had altered their houses and/or yards to protect themselves from future flooding.
- The average homeowner implemented three different floodproofing measures. The median costs of each ranged from $42 (standpipe or sewer drain plugs) to $2,350 (sewer backup valves), with most costing between $200 and $600).

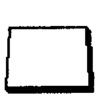
- Floodproofing measures were installed very soon after the flood. Where weather was not a factor, two-thirds of the projects were done within two months. Many of them were probably done in conjunction with repairs and reconstruction.
- Income, education, and sex were not determinants of who floodproofed. Sixty-five percent of the floodproofing measures implemented were financed entirely by the owners. However, those who received funds from disaster assistance or flood insurance were more likely to floodproof.
- Those who were flooded again in 1987 found that their floodproofing measures were generally effective. They also filed fewer flood insurance claims or applications for disaster assistance after the 1987 flood.
- Those homeowners who learned about what to do from personal contact with a contractor or someone who had floodproofed were more likely to implement something than those who learned about floodprooffing via the media, a manual, or a presentation.
- Most homeowners (71%) still want to undertake one or more floodproofing projects, even those who had not done so. Their primary reason for not undertaking projects is their inability to afford to.

The success of earlier floodproofing technical assistance efforts led the Illinois Housing Development Authority (IHDA) and the Department of Transportation's Division of Water Resources (DWR) to develop a program for funding floodproofing measures in selected, participating communities. DWR will provide up to $500,000 in low interest loans to enable victims of 1987 Chicago area floods to protect themselves from repeated damages from future flooding. The program involves cooperation of IHDA, cities, villages, counties, DWR, and local banks. Loans are to be made to install or construct flood or sewer backup protection measures as approved by local building departments. The funds may not be used for repairs or reconstruction (because there are already federal disaster assistance programs available for that) and would be restricted to residences of low and moderate income families in participating communities (Watson, 1988).

Kentucky has established a Community Flood Damage Abatement Program to provide financial assistance to communities for several types of flood control projects. At least one community has used funding from this program to support floodproofing.



Pennsylvania recently created a $100,000 loan program to encourage industrial floodproofing. The funds can be made available after a flood audit is conducted in cooperation with the Corps (Association of State Floodplain Managers, 1988).



In 1983, Colorado published the *Colorado Flood Proofing Manual* (Colorado, 1983).

Thirty-four states now provide information directly to interested property owners, either in the form of responses to inquiries or publications. Six states also provide some type of funding for floodproofing. Table 11-12 shows state and local activities related to floodproofing (Association of State Floodplain Managers, 1988).

Table 11-12. State and Local Activities Related to Floodproofing.

	STATE			LOCAL	
	INFORMATION	PUBLICATION	FUNDING	INFORMATION	FUNDING
Alabama	X				
Alaska	X	X			
Arizona	X				
Arkansas					
California	X				
Colorado	X	X			
Connecticut	X				
Delaware	X			X	
District of Columbia	X			X	
Florida	X				
Georgia					
Hawaii					
Idaho					
Illinois	X	X	X	X	
Indiana	X	X		X	X
Iowa	X				
Kansas	X				
Kentucky	X		X	X	X
Louisiana					
Maine	X				
Maryland	X			X	X
Massachusetts	X	X			
Michigan	X		X	X	
Minnesota	X		X	X	
Mississippi					
Missouri	X				
Montana	X			X	
Nebraska		X			
Nevada	X			X	
New Hampshire				X	
New Jersey	X			X	X
New Mexico					
New York	X				
North Carolina					
North Dakota	X	X			
Ohio	X				
Oklahoma	X			X	
Oregon					
Pennsylvania	X	X	X		
Rhode Island	X				
South Carolina	X				
South Dakota	X			X	
Tennessee	X				
Texas	X	X			
Utah	X	X	X	X	
Vermont					
Virginia					
Washington	X				
West Virginia					
Wisconsin				X	X
Wyoming					

NOTE: This table does not include the Community Development Block Grant or similar general purpose programs which may fund these activities.

Source: Association of State Floodplain Managers. "State Floodplain Management Programs. Results of a Survey Conducted by the Association of State Floodplain Managers for L.R. Johnston Associates," 1988.

Local Government Activities

Local government involvement with floodproofing has been largely on an individual basis — e.g., for floodproofing of individual structures. Where larger projects have been undertaken involving several municipal and/or private structures, state and federal governments have usually been involved.

In Kentucky several communities have used Community Development Block Grant (CDBG) funds from HUD to partially fund floodproofing efforts.

In Maryland, Howard County established a floodproofing loan program for local residents and commercial establishments using a combination of state and local funds. Prince George's County established a similar floodproofing loan program using 100 percent local funds. Maryland state officials estimate that about 15 commercial/industrial structures and 75 residences have been floodproofed using these programs.

In Indiana, the Cities of Fort Wayne and Kokomo have provided assistance to local citizens for floodproofing (Trakimas, 1988). The Bassetts Creek Flood Control Commission in Minnesota; the City of Tulsa, Oklahoma; Soldier's Grove, Wisconsin; and Rapid City, South Dakota are examples of other communities that have provided local funding (sometimes combined with federal and state funds) and/or technical assistance to local businesses and residences for floodproofing.

PRIVATE SECTOR

The primary role of the private sector has been the actual implementation of measures, such as raising a structure to a higher elevation, and installing shielding and closure devices. Practically all of the early expertise with floodproofing techniques originated with architects, engineers, and building contractors as they worked with homeowners and businesses to solve individual problems.

Beginning in the early 1960s, the federal government began to systematically evaluate much of this local expertise and to assess the best techniques and materials for different floodproofing situations. Much of the federal research was carried out in cooperation with the private sector, particularly professional associations. For example, the FIA has contracted with the American Institute of Architects, the National Association of Homebuilders, university researchers, and private engineering firms to actually perform the research and prepare the technical assistance information that the FIA has released over the last ten years.

While the private sector continues to be the primary implementor of floodproofing measures, some private companies also have undertaken research and development of new products. Prominent, current examples of these efforts include the development of vinyl sheathing and sewer backflow preventive devices to reduce flood damages to existing structures (Pomerantz, 1984). Other companies have developed and promoted replacements for standard sand bags, equipment for more efficient filling of traditional sand bags, and flood shields to be used for temporary closure of windows, doors and other openings in buildings.

The private sector has also been involved through incorporation of floodproofing standards and guidelines in the major model building codes. The standards committees of the building code organizations have worked with FEMA and other government agencies in selecting provisions appropriate for inclusion in the codes. This has particular importance because most states and communities have now adopted for use one of the model building codes, although many communities and some states continue to have their own codes (Federal Emergency Management Agency, 1986).

CURRENT STATUS OF FLOODPROOFING AND ELEVATION

Floodproofing and/or elevation is now routinely incorporated into the design of most new structures to be located within the floodplain. Research over the past 20 years has shown new and improved methods of construction that can enable structures to better withstand the hydrostatic and hydrodynamic forces of water. In coastal areas, techniques to combat the effects of scour and high wind are also part of the construction techniques. Regulations of all communities participating in the NFIP require that new residential structures be elevated above the one percent annual chance flood level. For construction in coastal high hazard areas, floodproofing in lieu of elevating a structure is not an acceptable alternative. Also, in coastal high hazard areas certifications are required by a registered professional engineer or architect that the design and methods of construction to be used are in accordance with accepted standards of practice for the breakaway wall criteria and the anchoring requirements for elevated buildings.

In 1966, House Document 465 noted that floodproofing can provide for development in lower risk floodplain areas by keeping damage within acceptable limits. However, floodproofing for new construction is not being restricted to use in low risk floodplains. In some cases floodproofing is being used to build structures in high risk areas that perhaps would not be built on without knowledge of improved construction techniques.

While new construction is routinely either elevated above a specified flood level or constructed so as to prevent water from entering the structure and causing damage, floodproofing of existing structures (retrofitting) has been much less widespread. In the last few years new research on retrofitting methods has been conducted and information is being made available regarding reliable methods for retrofitting existing structures. However, this information is not yet routinely used by architects and engineers.

As part of a 1984 review of floodproofed structures, the Corps contacted each of its field offices regarding the number of known floodproofing projects in their regions. The Corps concluded that use of floodproofing measures was "widespread" but was unable to make any estimate of the number of floodproofed structures nationwide (Plott, 1987). In a survey of each of the states conducted for this assessment, only a few states were able to provide any estimates of the number of floodproofed structures within their state (Association of State Floodplain Managers, 1988b).

These results are not particularly surprising. The fact that most floodproofing is carried out by individual property owners without governmental assistance, and the absence of any procedure for reporting and recording floodproofed structures, combine to render any estimate of the number of floodproofed structures impractical. Although no estimate is available of the number of individually floodproofed structures, there are millions of existing floodprone homes to which floodproofing techniques could usefully be applied (Federal Emergency Management Agency, 1989).

Although several states and communities, as well as the federal government, have implemented information and education programs regarding floodproofing, the vast number of structures that may benefit from some form of floodproofing requires a much greater information and education effort. Information must be provided to individual homeowners and businesses regarding best techniques, advantages and disadvantages, and sources of funding and technical assistance (Larson, 1989). Even with an increased education effort, more widespread application of tested floodproofing techniques will likely be hindered by the inability of individual property owners to receive a rate reduction on their flood insurance premium for investments in floodproofing (Myers, 1989). The new Community Rating System which provides credit to a community for floodproofing practices, and a potential reduction in individual flood insurance rates, may help to offset this obstacle.

Floodproofing and elevation are being widely used throughout the United States as flood damage reduction measures. Over the years, many existing structures have been floodproofed and a substantial number of new structures have incorporated floodproofing or elevation features into their designs. However, there are still many more existing structures and structures under construction that need floodproofing.

Like other flood damage reduction measures, floodproofing and elevation have their limitations. Floodproofing seldom provides complete protection. Even the best system will not protect against floods that exceed the design elevation. Improperly designed or poorly constructed floodproofing schemes can cause even greater flood damages than would have occurred without them. There is also an inherent danger that installed floodproofing systems will create a false sense of security and thereby encourage people to remain in floodproofed buildings during floods, thus exposing them to a life threatening risk. The effectiveness of floodproofing is therefore relative not only to how it performs but also to how it is perceived and expected to perform.

Floodproofing methods and materials have been continuously improved and refined and when used properly are very effective. However, in almost all cases, they require professional engineering and qualified contractors for correct design and installation. The willingness of individual property owners to consider floodproofing and their ability to pay for the design and installation are major contributing factors towards effective floodproofing. More use of floodproofing and elevation, under the right circumstances, will increase the potential to improve effectiveness.

When properly planned, designed, and installed, floodproofing and elevation have resulted in significant reductions in flood damages. Based on past trends, it is evident that these measures will continue to be used. However, the overall level of the effectiveness of floodproofing and elevation remains to be determined.

SUMMARY AND CONCLUSIONS

Nonstructural measures to modify an individual's or community's susceptibility to flood damages and disruption have been the major focus of flood loss reduction efforts over the past 20 years. While several tools are available to reduce susceptibility to damages, floodplain regulation has been the most widely used and appears to have had the greatest impact. As a result of participation in the National Flood Insurance Program, over 17,000 communities have adopted at least minimal floodplain regulations. Many states and communities have also adopted more stringent regulations than required by the NFIP. Enforcement of floodplain regulations, however, remains inadequate for many communities. Regulations, though generally accepted, are unpopular with many affected property owners, and communities often do not have the resources needed for diligent enforcement. Without enforcement, inappropriate construction will continue to occur in floodplains. Regulations do little to protect or reduce the large inventory of floodplain structures built prior to the adoption of floodplain regulations. Nor do they protect natural and cultural resources. To the extent that they permit further development they may actually contribute to the loss of these resources.

Executive Order 11988, the major federal policy concerning development and redevelopment in floodplains, firmly establishes the one percent annual chance floodplain as the minimum area for floodplain management and the application of flood loss reduction measurers. Many states have developed similar policy through executive orders or legislation. Other policies seek to avoid development in the floodplain and to ensure that flood control and other types of government projects take into consideration the flood risk to the project, potential flood risk off-site of the project, and potential loss of floodplain natural and cultural resources. While these policies have great potential, application has been spotty, there is often conflict with other policies and legislative mandates, and there may be court challenges.

Acquisition of undeveloped land to avoid flood losses is a little-used technique. More common is acquisition of flood-damaged properties to permanently remove them from the floodplain. Typically, acquisition and relocation projects have involved both financial and technical input from all levels of government. Permanent relocation from the floodplain is typically used only in instances of severe or repetitive flooding, and when structural flood control measures are not practical. Despite the risk and inconvenience, individual residents are often reluctant to relocate from properties near the water that provide many benefits, and their opposition to relocation signals the end of many relocation projects. Some of the most successful acquisition and/or relocation projects have incorporated flood loss reduction goals with other community goals.

Development of automated flood warning systems that employ near real-time collection of precipitation and streamflow data hold great promise for increasing warning time and reducing losses in remote locations and areas subject to flash flooding. Problems with implementing and maintaining these various systems have developed, and as yet there is limited experience with the systems during actual floods. Too often, forecast and warning systems are not linked with a response plan, thereby making an otherwise good forecast and warning system ineffective.

Floodproofing has long been used by individual property owners, although most private floodproofing efforts have been implemented without knowledge of the chosen method's general effectiveness.

Significant research into effective floodproofing measures, however, has been conducted in recent years. Effective construction practices for new residential and nonresidential development in coastal and riverine areas have been identified, and methods for retrofitting existing structures have been researched and documented. Since floodproofing is essentially a technique to be used by individual property owners, the task of providing potential candidates with proper information is formidable. To date this challenge has not been successfully met.

Each of these tools has been used successfully, but seldom is a single floodplain management tool adequate to address a community's flooding problems. As a result, the available tools have often been used in various combinations. Still, development and implementation of a comprehensive plan to address a community's flood problems is not common. Particularly lacking is recognition that floods are natural events with beneficial effects that should be accommodated rather than eliminated; that controls are needed on activities occurring outside the floodplain to avoid aggravating an existing flood problem; and that all areas of the floodplain need not be treated the same. The flood risk is greater or less at different locations within the floodplain, and different approaches and the application of different tools may be needed to effectively address the flood risk and protect natural resources.

CHAPTER 12:

MODIFYING FLOODING

Flood control projects have saved billions of dollars in property damage and protected hundreds of thousands of people from anxiety, injury and death.

Joseph L. Arnold, *The Evolution of the 1936 Flood Control Act*,
U.S. Army Corps of Engineers, 1988

As described in *A Unified National Program for Floodplain Management* (1986), the traditional strategy of modifying flooding relies on the following tools:

- construction of dams and reservoirs;
- construction of dikes, levees and floodwalls;
- channel alterations;
- high flow diversions and spillways; and
- land treatment measures.

Flooding can also be modified by two additional tools:

- shoreline protection; and
- stormwater management.

These several tools, often referred to as "structural" measures, are further described in this chapter. The application of structural measures can affect changes in the volume of runoff, peak flood stage, time of rise and duration of floodwater, location of flooding, extent of area flooded, and velocity and depth of floodwater. These changes influence the amount of debris, sediment, and pollutants carried by floodwater.

The effectiveness of structural measures for protecting property and saving lives has been well demonstrated throughout history. Dams have been built in other parts of the world since ancient times, and there is archaeological evidence of dam construction dating back 6,000 years. Indeed, throughout much of this century, structural measures were the sole means of addressing many flood problems. Today, floodplain regulations, warning systems, and other "nonstructural" measures are commonly, but not universally, used in concert with flood control measures. The nonstructural measures help to avoid inappropriate development of floodplain areas protected by flood control structures. The nonstructural measures also provide alternative protection against flood damages in the event of structural failure or flows in excess of design capacity.

INVESTMENT IN FLOOD CONTROL

The traditional approach to reducing flood losses has involved attempts to control floodwater. As a result of devastating floods and the potential for catastrophic flood losses, the Nation invested heavily in the construction of dams and reservoirs, alteration of channels, and other flood control structures during the first seven decades of this century. The U.S. Water Resources Council (WRC) estimated that between 1936 and 1975 the federal government spent more that $13 billion for dams and other structures such as levees, floodwalls, and channel work. At the same time, there was also a substantial, but unquantified, investment in nonfederal flood control measures (U.S. Water Resources Council, 1977). Since the 1970s, nonstructural floodplain management measures have become more prominent, but structural measures to control floodwater are still necessary, important, and widely used. Many communities and floodplain residents continue to prefer structural measures.

It appears that most of the potential large flood control structures have been built. New flood control structures tend to be smaller in size and designed to protect a smaller area. A marked shift in the financing of flood control projects has also occurred. Early in this century most flood control projects were completely financed by the federal government. Cost-sharing with state and local governments and with private sponsors, however, has now increased, and some form of cost-sharing is now required for practically all flood control projects.

The Water Resources Development Act of 1986 (P.L. 99-662) increased the nonfederal share for construction of most water resource projects, including flood control projects. Cost-sharing provisions specifically for flood control were applied only to U.S. Army Corps of Engineers' (Corps) projects and required a moderate increase in nonfederal responsibility. Prior to P.L. 99-662, nonfederal responsibility for Corps flood control projects ranged from 20 to 50 percent of construction costs. P.L. 99-662 increased the minimum nonfederal share to 25 percent while retaining the maximum of 50 percent. A larger increase in nonfederal responsibility was introduced for other types of water resources projects (Schilling and others, 1987).

Concerns about the environmental impacts of structural flood control measures have also contributed to a reduction in the number of flood control projects, particularly large projects, implemented in recent years. Dams and reservoirs, levees and floodwalls, and channelization work can all produce a number of adverse impacts on wildlife habitat, scenic values, and water quality. These potential impacts are frequently seen to outweigh the beneficial impacts of structural flood control projects, including the creation of recreational opportunities and different types of wildlife habitat.

FEDERAL INVESTMENTS

Federal involvement in flood control became significant when the Mississippi River Project was authorized by the Flood Control Act of 1928. The problem of Mississippi River flooding was regional in scope and beyond the authority and capacities of state and local governments to address on their own. The Corps was designated to undertake a massive program of building levees, reservoirs, and floodwalls throughout the Mississippi River system, supplemented by a comprehensive system of flood control reservoirs on the Arkansas, Missouri, Ohio, Red, Upper Mississippi, and White rivers and other Mississippi River tributaries. The federal government was responsible for 100 percent of the cost of the Mississippi River Project.

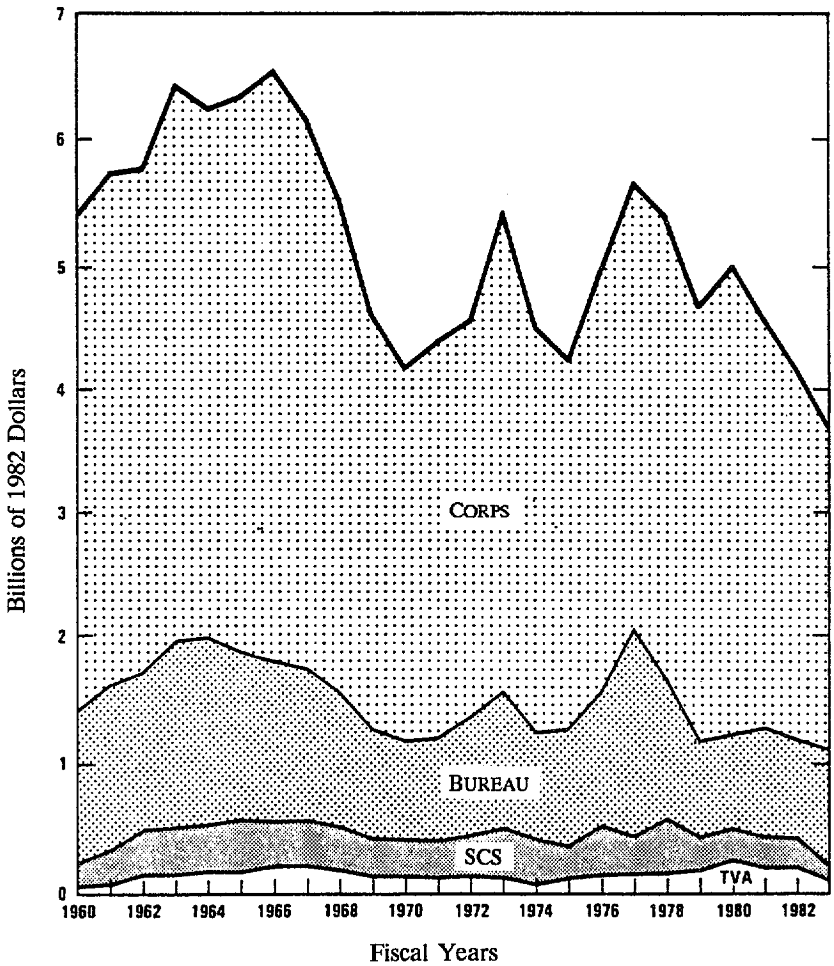
The nationwide program for flood protection, contained in the Flood Control Act of 1936, established the federal interest in controlling floods in navigable waters and their tributaries. The Act authorized $310 million to carry out flood control projects along river basins, and assigned major responsibilities for mainstream and downstream projects to the Corps of Engineers. The Soil Conservation Service (SCS) was also assigned responsibilities for flood protection projects on upstream watersheds. The Flood Control Act established the condition that federal involvement in flood control would be appropriate "... if the benefits to whomsoever they may accrue are in excess of the estimated costs and if the lives and social security of the people are otherwise adversely affected." This one phrase has been the basis for 50 years of efforts to develop techniques for analyzing the benefits and costs of water resources projects.

In addition to the Corps and the SCS, the Bureau of Reclamation (BOR) and the Tennessee Valley Authority (TVA) are involved in the construction of flood damage prevention structures. The BOR has planned and constructed many large irrigation and hydropower reservoir projects in the western United States and these projects also provide flood control. Some of the BOR's more important projects include Grand Coulee Dam, Central Valley Project, Hoover Dam, North Platte Project and the Colorado River Storage Project. Since its creation in 1933, the TVA has also played a major role in flood control. Two of its legislated purposes are "to improve navigation in the Tennessee River and to control destructive floodwaters in the Tennessee River and Mississippi River Basin" (Tennessee Valley Authority, 1983).

Of the roughly $3.4 billion spent by all four of the major federal water resource agencies in 1986, the Corps accounted for 70 percent, the BOR for 21 percent, the SCS for eight percent, and the TVA for one percent. As shown on Figure 12-1, the relative shares of these four agencies for water resources projects has been at this level for some time. The Corps has been the lead agency for projects involving inland waterways, commercial harbors, and urban flood control, while the BOR has been the lead agency for irrigation (with high rural flood control involvement as well) (Schilling, 1987). Figure 12-2 shows that in 1986, about 39 percent of the Corps' total outlay for water resources projects was spent on flood control (not including flood control projects for the Mississippi River and tributaries) (National Council on Public Works Improvement, 1988).

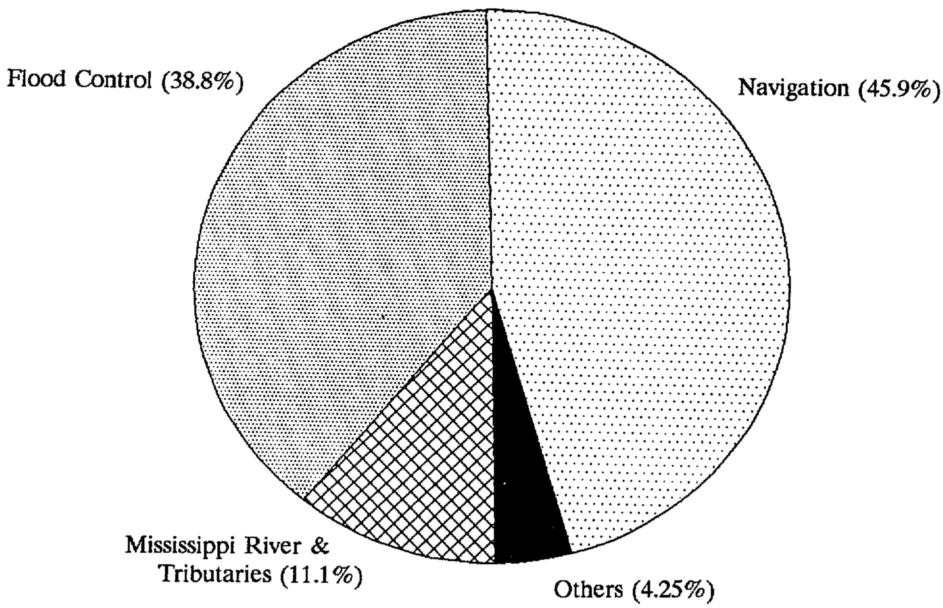
Although total Corps outlays for the flood control projects fluctuated considerably in the 1960s and 1970s, outlays have remained relatively stable at around $1.1 billion since 1982, as shown on Figure 12-3. This total includes spending for: construction, operation, and maintenance; emergency flood control; and a special flood control program for the Mississippi River and its tributaries. SCS expenditures fluctuated between $31 and $217 million between 1960 and 1987, averaging about $82 million per year. As shown on Figure 12-4, construction outlays by the Corps peaked in the mid-1960s, again in the early 1970s, and fell to about $550 million in 1987. This falloff in capital outlays occurs largely because Congress made no significant new project authorizations from the mid-1970s until 1986 when the Water Resources Development Act of 1986 was enacted. Corps of Engineers' operation and maintenance outlays have continued to increase over this period, from about $20 million in 1960 to $200 million in 1987 (National Council on Public Works Improvement, 1988).

WATER RESOURCES DEVELOPMENT APPROPRIATIONS FOR THE U.S. ARMY CORPS OF ENGINEERS (CORPS), BUREAU OF RECLAMATION (BUREAU), SOIL CONSERVATION SERVICE (SCS), AND TENNESSEE VALLEY AUTHORITY (TVA)



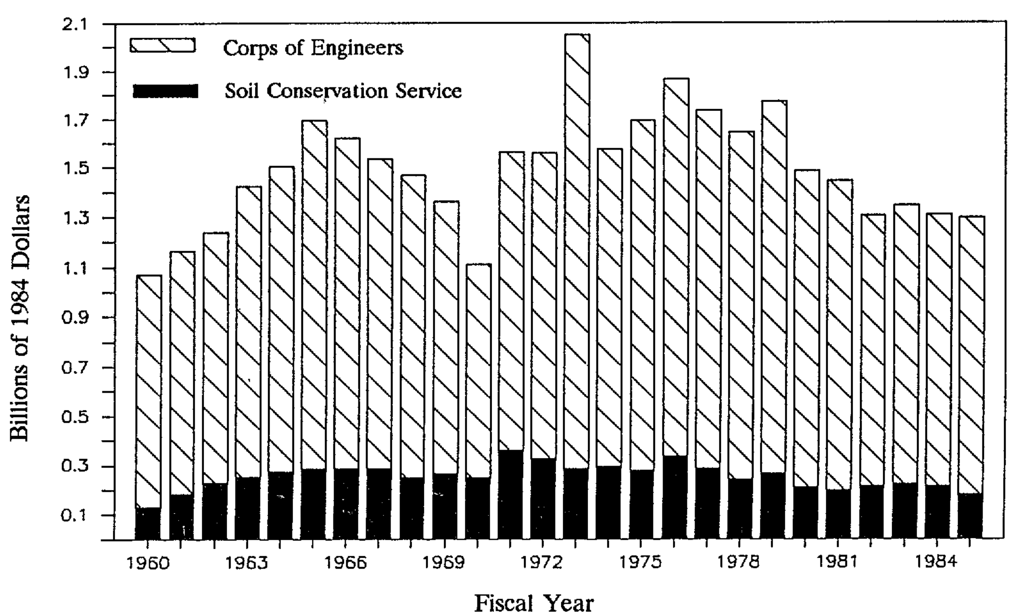
Source: Schilling, Kyle, and others. The Nation's Public Works: Report on Water Resources. Categories of Public Works Series. Washington, D.C.: National Council on Public Works Improvement, 1987.

Figure 12-1. Federal Agency Shares of Water Resources Spending.



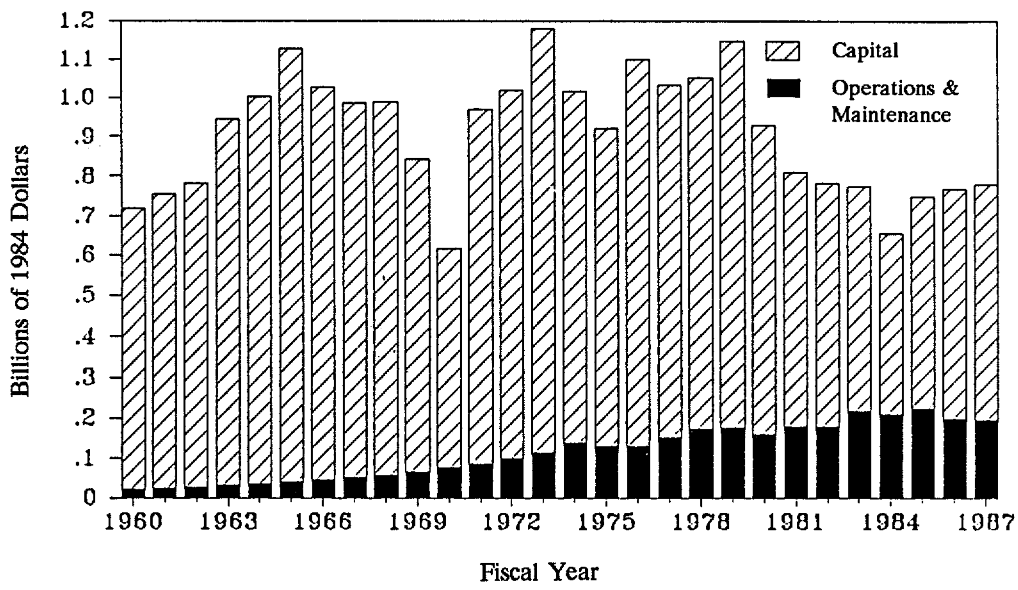
Source: National Council on Public Works Improvement. Fragile Foundations: A Report on America's Public Works, Final Report to the President and the Congress. Preprint. Washington, D.C., 1988.

Figure 12-2. Total 1986 Project Outlays by the U.S. Army Corps of Engineers.



Source: National Council on Public Works Improvement. Fragile Foundations: A Report on America's Public Works, Final Report to the President and the Congress. Preprint. Washington, D.C., 1988.

Figure 12-3. Outlays for Corps of Engineers and SCS Flood Control Programs, 1960-1985.



Source: National Council on Public Works Improvement. Fragile Foundations: A Report on America's Public Works, Final Report to the President and the Congress. Preprint. Washington, D.C., 1988.

Figure 12-4. Construction and Operations & Maintenance Costs for the Corps of Engineers Flood Control Program.

STATE AND LOCAL INVESTMENTS

Tremendous variations exist in thė water resources programs operated at the state and local levels. Development of these programs is primarily motivated by local needs and budgets, and by shortfalls in federal programs. States may view nonfederal projects as a totally local responsibility or they may be very active in funding. States and local governments play two major roles in funding water resources development. First, they construct and operate their own water resources projects, and second, they finance and maintain the nonfederal share of federal water projects.

A report by the U.S. Water Resources Council (WRC, 1981) presented information on state water planning capabilities. The WRC found that 35 states had specific legislative or administrative authority for some type of comprehensive water resources planning. The technical capabilities of states with respect to water resources planning, engineering, and construction were found to be diverse. Generally, the emphasis was on funding for water resources planning activities, rather than project construction.

In addition, the WRC found that most states combined their water quality-related activities with water quantity activities, with water quality being the lead concern and other water resources concerns assigned lesser priority. The majority of reported water quantity-related activities appeared to be for water supply, not for flood control, dam safety, urban drainage, or other flood-related activities.

Twenty-two states had comprehensive water quantity planning programs and a mandate to continue those programs. In addition, the WRC found that western states have tended to integrate water quantity planning and management functions in a single agency, while in the Northeast it is more likely that water quality and water quantity planning functions are spread among several agencies.

Many federal water resources development programs were initiated at a time when state and local government capabilities were less developed than at the present time. Over the last 20 years, state and local capabilities to provide financial, technical, and management assistance for water resource programs have grown significantly. As a result, and in response to the decline in water resources development on the federal level, many states have expanded their ongoing programs. A 1983 Congressional Budget Office (CBO) report notes that state bonding activity had increased seven-fold since 1959, and that over the three-year period 1981-1983, all states combined issued almost $8 billion in water-related general obligation and revenue bonds. The CBO report pointed out that some states have created new programs to deal with growing water problems. It noted, for example, that Florida had created Water Management Districts authorized to levy ad valorem taxes to finance local water projects. In Montana, a water development fund was created in 1981 to make loans and grants for all water development purposes (National Council on Public Works Improvement, 1988).

As of 1988, twenty-four states provided technical (planning) assistance to communities for flood control (Table 12-1, column 1). Louisiana, Maryland, and Minnesota have recently created programs that provide financial assistance to communities that develop flood control or flood hazard mitigation plans. The State of Washington provides grants to communities to help maintain levees and other flood protection projects. Many more states are directly involved in other ways with projects for structural flood control, most commonly through cooperation with federal projects. Several states act as local sponsors or fund the nonfederal share for projects designed and built by the Corps of Engineers and the SCS (Association of State Floodplain Managers, 1988).

At the local level, there are also a great number of institutions with a role in water resources development and management. Most of the formalized local institutions are involved with wastewater treatment and water supply. The 1982 U.S. Census of Governments noted about 9,400 special purpose districts providing one or more water management services. Over 85 percent of those districts were single-function districts (e.g., port, drainage, flood control, irrigation districts), with the remainder being multi-function districts (e.g., sewer and water supply, flood protection and water supply, natural resources and water supply districts). About 47 percent of the special purpose districts identified were concerned with water resources-related functions (e.g., port operation, drainage, flood control, irrigation, and reclamation). Local governments appear to see their role as one of providing mostly water supply and wastewater treatment services (Schilling, 1987).

Table 12-1. State Activities to Modify Flooding.

	PLANNING ASSISTANCE	STRUCTURAL PROJECTS	PROJECT FUNDING	DAM SAFETY INSPECTIONS	REGULATION OF LEVEES
Alabama	X	X	X		
Alaska	X			X	
Arizona		X	X	X	X
Arkansas				X	
California	X	X		X	X
Colorado	X	X	X	X	
Connecticut	X	X	X	X	
Delaware	X	X	X	X	
District of Columbia					
Florida	X	X		X	X
Georgia	X			X	
Hawaii		X		X	
Idaho		X		X	X
Illinois	X	X	X	X	
Indiana	X	X	X	X	X
Iowa				X	X
Kansas		X		X	X
Kentucky			X	X	
Louisiana	X		X	X	
Maine	X			X	
Maryland	X	X	X	X	X
Massachusetts		X		X	
Michigan	X				
Minnesota	X	X	X	X	
Mississippi				X	
Missouri				X	
Montana	X			X	
Nebraska		X		X	
Nevada		X	X		
New Hampshire				X	
New Jersey		X	X	X	
New Mexico				X	
New York	X	X	X	X	
North Carolina	X	X	X	X	
North Dakota	X	X	X	X	X
Ohio		X	X	X	X
Oklahoma	X			X	
Oregon				X	
Pennsylvania	X	X	X	X	X
Rhode Island				X	
South Carolina				X	
South Dakota				X	
Tennessee	X				
Texas		X		X	X
Utah	X	X	X	X	
Vermont				X	
Virginia				X	
Washington		X	X	X	
West Virginia	X			X	
Wisconsin					X
Wyoming				X	

Source: Association of State Floodplain Managers. "State Floodplain Management Programs. Results of a Survey Conducted by the Association of State Floodplain Managers for L.R. Johnston Associates," 1988.

DAMS AND RESERVOIRS

Storage of floodwater in reservoirs can reduce flood flow rate, the extent of the area flooded, and the timing of peak floods. While dams and reservoirs may be constructed solely for flood control purposes, flood control is most often only one of several objectives served by multi-purpose dams and reservoirs.

In areas that are already well-developed with structures and uses subject to damage from flooding, temporary storage of floodwater in a reservoir may be the only feasible means — short of permanent evacuation of the floodplain — of reducing potential flood damages. Even though the potential for flood damage may be greatly reduced by reservoir storage, the damage potential remains if a flood of greater than design capacity occurs or if the dam should fail.

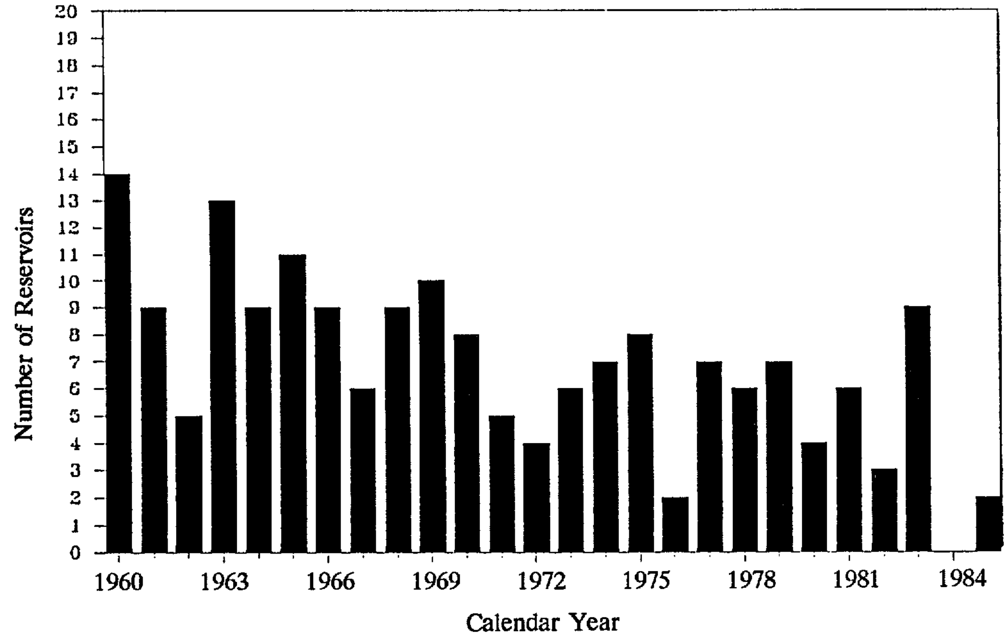
Although the total number of dams of all types and sizes in the United States is unknown, when small dams (such as dams for farm ponds) are considered, the total appears to be several million. In support of such a large number, the SCS estimates that as of 1977 it had been involved in the design or construction of over 2.5 million dams. Almost 1.1 million of these dams were pond dams, indicating that most of the SCS-assisted dams are rather small (Buie, 1979). In 1982, the Corps inventoried more than 66,000 dams of all types in the United States. The dams inventoried were either in excess of six feet in height with a capacity of at least 50 acre-feet, or at least 25 feet high with a capacity of at least 15 acre-feet (U.S. Army Corps of Engineers, 1982). Also, the 1989 Report on Review of Status of Nonfederal Dam Safety Programs conducted for the Association of State Dam Safety Officials (ASDSO) and the Federal Emergency Management Agency (FEMA) reported that about 80,000 dams were regulated by the states.

FLOOD CONTROL CAPACITY

The Nation's dams and reservoirs include those owned by the federal government as well as nonfederal dams and reservoirs, many of which are regulated by federal authorities.

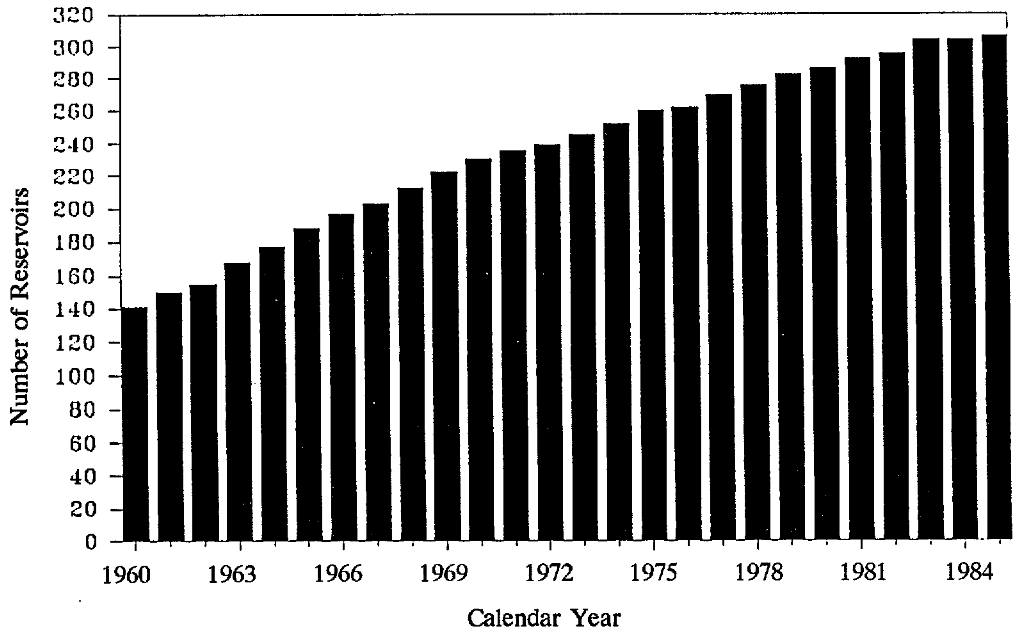
Federal Dams and Reservoirs

More than 20 federal agencies and four independent offices and commissions own approximately 4,000 dams, have regulatory authority over approximately 6,000 nonfederal dams, and have various other responsibilities for additional tens of thousands of nonfederal dams (Federal Emergency Management Agency, 1990). Over 300 dams and reservoirs owned by the Corps have been built primarily for flood control. Other federal agencies, including the SCS, the TVA, and the BOR, build and operate a less extensive array of flood control structures. Figures 12-5 and 12-6 indicate that while the number of flood control reservoirs built by the Corps has doubled since 1960, the actual rate of increase has declined. These data suggest three distinct periods in the construction of new flood control reservoirs: the 1960s, when facilities grew by an average of 6 percent a year; the 1970s, when facilities were added more slowly — about two percent a year; and the 1980s, when net additions slowed even further — less than one percent a year. Figure 12-7 shows that the cumulative flood control storage in Corps flood control reservoirs grew steadily in the 1960s and 1970s, but has leveled off since the late 1970s.



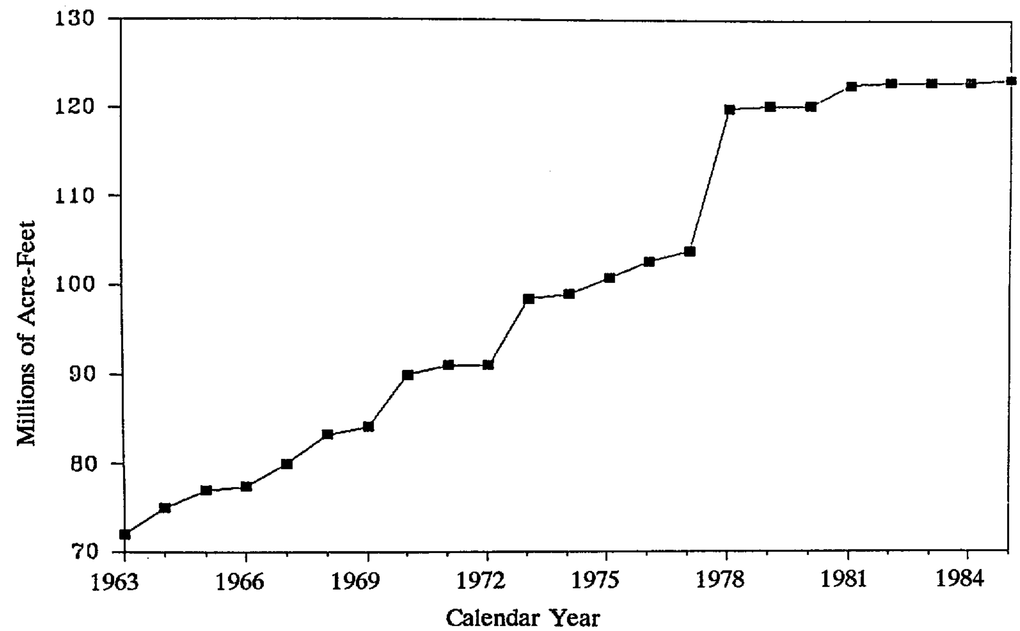
Source: National Council on Public Works Improvement. Fragile Foundations: A Report on America's Public Works, Final Report to the President and the Congress. Preprint. Washington, D.C., 1988.

Figure 12-5. Number of Flood Control Reservoirs put in Service by the Corps of Engineers.



Source: National Council on Public Works Improvement. Fragile Foundations: A Report on America's Public Works, Final Report to the President and the Congress. Preprint. Washington, D.C., 1988.

Figure 12-6. Number of Corps of Engineers Flood Control Structures in Service.

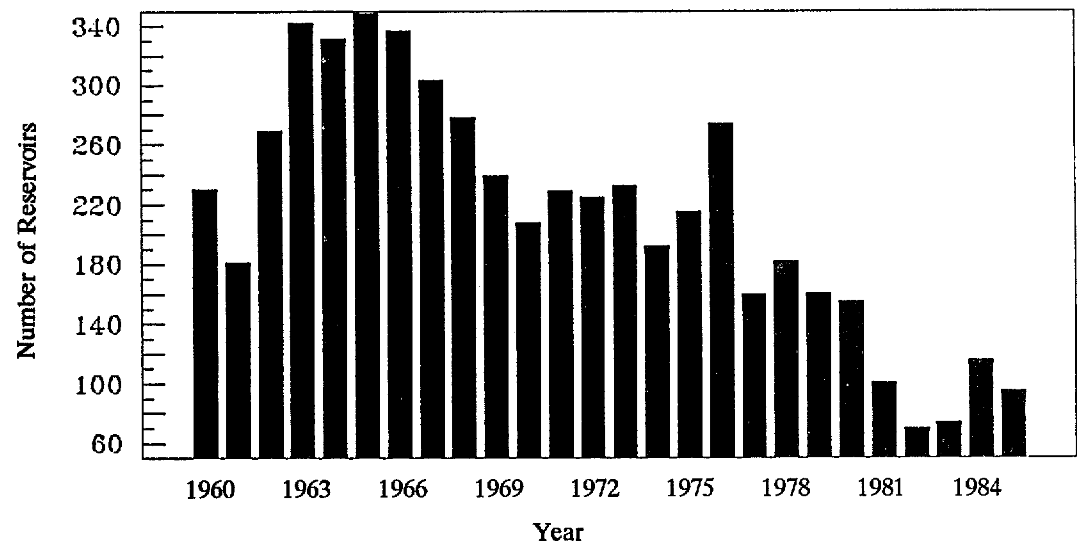


Source: National Council on Public Works Improvement. Fragile Foundations: A Report on America's Public Works, Final Report to the President and the Congress. Preprint. Washington, D.C., 1988.

Figure 12-7. Cumulative Storage in Corps of Engineers Flood Control Reservoirs.

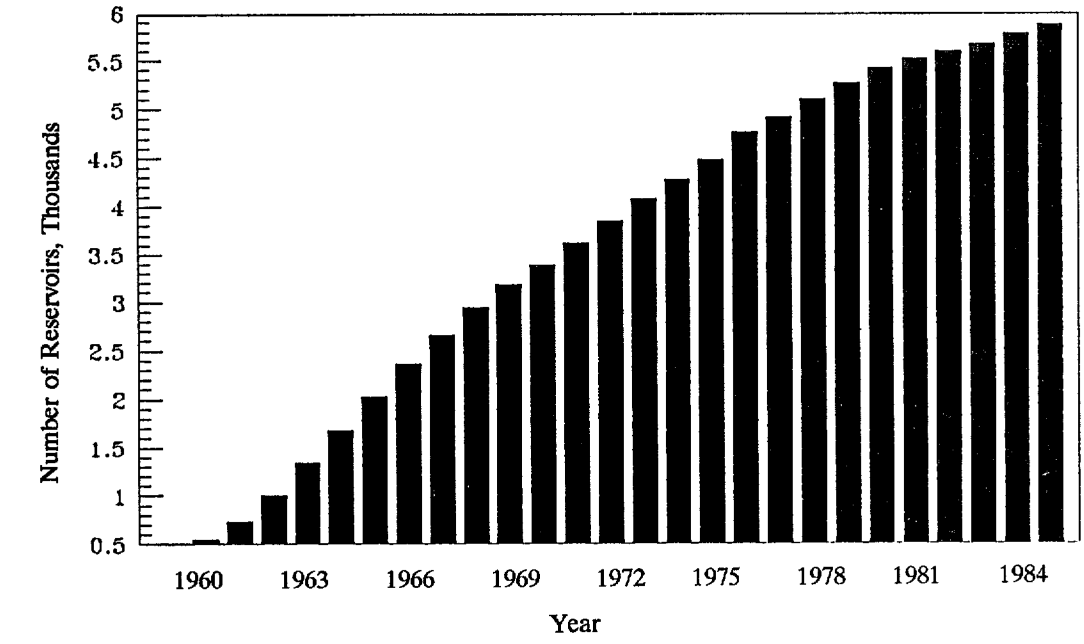
Within the Corps of Engineers' Southwestern Division, which consists of Oklahoma, Texas, and parts of Colorado, Louisiana, and New Mexico, there is over 50 million acre-feet of flood storage, or 31 percent of all such storage space in Corps reservoirs nationwide. The Missouri River and Ohio River Divisions are also responsible for managing significant portions (20 and 14 percent, respectively) of the nationwide total of flood storage space provided by the Corps. In the lower Mississippi Valley, flood control facilities built and maintained by the Corps contain storage space for approximately 16 million acre-feet of water (National Council on Public Works Improvement, 1988).

Data from the SCS's Small Watershed Program show a peak of facilities construction in the 1960s that has since slowed dramatically. Total facilities have increased significantly since 1960, but the rate of construction has slowed in the 1980s (see Figures 12-8 and 12-9) (National Council on Public Works Improvement, 1988).



Source: National Council on Public Works Improvement. Fragile Foundations: A Report on America's Public Works, Final Report to the President and the Congress. Preprint. Washington, D.C., 1988.

Figure 12-8. Number of Flood Control Reservoirs put in Service by the Soil Conservation Service.



Source: National Council on Public Works Improvement. Fragile Foundations: A Report on America's Public Works, Final Report to the President and the Congress. Preprint. Washington, D.C., 1988.

Figure 12-9. Number of Soil Conservation Service Flood Control Reservoirs in Service.

Nonfederal Dams and Reservoirs

Table 12-2 lists the number of nonfederal dams constructed for different purposes in each decade of this century (data are not available to show multipurpose dams). As of 1980 there were almost 10,000 nonfederal dams (at least six feet high with a capacity of at least 50 acre-feet, or at least 25 feet high with a capacity of at least 15 acre-feet) constructed for the primary purpose of flood control. Of the over 63,000 nonfederal dams, 8,818 were inspected in 1980, and 2,925 were found to be unsafe. Table 12-3 shows the storage capacity of nonfederal dams. Table 12-4 shows a steady and dramatic decrease in the number of dams completed each year from 1961 through 1981.

Table 12-2. Number of Nonfederal Dams Constructed by Major Purposes and Decade.

	CONSTRUCTION PERIOD									
PURPOSE	1700-1899	1900-1910	1911-1920	1921-1930	1931-1940	1941-1950	1951-1960	1961-1970	1971-1980	TOTAL
Irrigation	282	548	639	388	537	695	1,474	1,293	885	6,741
Hydropower	125	189	224	277	104	112	109	93	40	1,273
Flood control	61	68	35	51	128	158	1,937	4,709	2,481	9,628
Water supply	510	475	423	483	769	810	1,801	1,603	629	7,503
Recreation	1,290	986	673	987	1,736	2,239	4,908	6,148	2,941	21,890
Navigation	23	23	16	8	53	4	16	45	21	209
Debris control	3	6	4	3	6	17	66	177	178	460
Stock pond	68	70	55	135	910	1,269	2,787	3,782	2,386	11,462
Other	299	161	157	134	295	295	648	1,238	1,024	4,175
TOTALS	2,661	2,508	2,226	2,466	4,538	5,523	13,746	19,088	10,585	63,341
CUMULATIVE	2,661	5,169	7,395	9,861	14,399	19,922	33,668	52,756	63,341	
% 1980 TOTAL	4.2	8.2	11.7	15.6	22.7	31.5	53.2	83.3	100.0	

Source: U.S. Army Corps of Engineers. National Program of Inspection of Non-Federal Dams, 1982 (from Table 10).

Table 12-3. Storage Capacity of Nonfederal Dams Constructed by Decade and Cumulative.

CONSTRUCTION PERIOD	STORAGE CAPACITY (Acre-ft)	CUMULATIVE CAPACITY (Acre-ft)	% OF 1980 CAPACITY
1700-1899	9,758,000	9,758,000	1.1
1900-1910	15,272,000	25,030,000	2.9
1911-1920	27,432,000	52,462,000	6.1
1921-1930	69,365,000	121,827,000	14.1
1931-1940	106,241,000	228,068,000	26.3
1941-1950	80,807,000	308,875,000	35.6
1951-1960	210,939,000	519,814,000	60.0
1960-1970	251,833,000	771,647,000	89.0
1971-1980	95,475,000	867,122,000	100.0

NOTE: The storage capacity doubled between 1956 and 1980.

Source: U.S. Army Corps of Engineers. National Program of Inspection of Non-Federal Dams, 1982 (from Table 4).

Table 12-4. Construction of Nonfederal Flood Control Dams, 1961-1981.

YEAR	DAMS CONSTRUCTED
1961	432
1962	437
1963	599
1964	498
1965	622
1966	499
1967	481
1968	422
1969	391
1970	328
1971	290
1972	334
1973	287
1974	275
1975	271
1976	289
1977	262
1978	228
1979	129
1980	116
1981	27

Source: U.S. Army Corps of Engineers. National Program of Inspection of Non-Federal Dams, 1982 (from Table 10).

DAMAGE REDUCTION ATTRIBUTABLE TO FLOOD CONTROL STRUCTURES

No estimates are available of the damages prevented by the Nation's total inventory of flood control dams. Estimates prepared by the Corps and the TVA, however, provide a good indication of the amount of damage prevented.

The Corps estimates that the number of communities protected by its flood control dams has basically increased in proportion to the number of dams placed in service. No accurate account of the actual number of people protected by these dams, however, is available (National Council on Public Works Improvement, 1988).

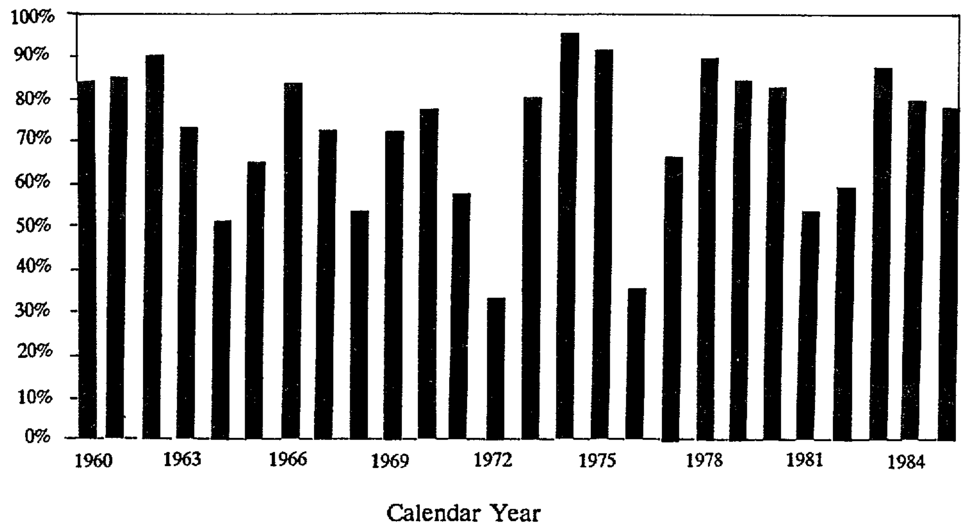
Between 1960 and 1985, it is estimated that Corps projects prevented an estimated $245 billion (1985 dollars) in potential damages as shown in Table 12-5. Figure 12-10 compares estimates of damages averted with estimates of the total damages that would have occurred if there was no flood control program.[1] On average, Corps' dams prevented an estimated 78 percent of potential damages (National Council on Public Works Improvement, 1988).

[1] One problem with this comparison is that it is based on the assumption that floodplains would have been equally developed in the absence of flood protection. While this is not necessarily true, there is no way to accurately project induced floodplain growth.

Table 12-5. Damages Prevented by Corps of Engineers Flood Control Structures.

YEAR	FLOOD CONTROL VOLUME (million acre-ft.)	DAMAGES PREVENTED (Current) (billions $)	1985 $
1960	(*)	0.5	1.82
1961	(*)	0.9	3.24
1962	(*)	0.7	2.49
1963	(*)	0.5	1.76
1964	(*)	0.7	2.43
1965	(*)	1.5	5.11
1966	77.5	0.6	1.99
1967	80.1	1.0	3.22
1968	83.5	0.4	1.24
1969	84.4	2.4	7.04
1970	90.2	0.8	2.22
1971	91.3	0.4	1.06
1972	91.3	2.3	5.92
1973	98.7	11.9	28.81
1974	99.2	13.0	28.37
1975	101.0	15.9	31.78
1976	102.9	1.7	3.21
1977	104.0	2.6	4.62
1978	120.1	6.3	10.39
1979	120.4	19.4	28.75
1980	120.4	7.3	9.53
1981	122.7	1.2	1.42
1982	123.0	4.3	5.41
1983	123.0	23.2	25.05
1984	123.0	16.8	17.04
1985	123.3	10.8	10.80
TOTAL	2080	147.10	244.72

Source: U.S. Army Corps of Engineers. Annual Reports of the Chief of Engineers. Statistical Highlights from different years.



Source: National Council on Public Works Improvement. Fragile Foundations: A Report on America's Public Works, Final Report to the President and the Congress. Preprint. Washington, D.C 1988.

Figure 12-10. Annual Damages Prevented as a Percent of Total Possible Damages.

The TVA prepares estimates of flood damages prevented by its dam and reservoir system, and reports that over the years its multipurpose dam and reservoir system has prevented damages that would have amounted to nearly $3.03 billion. At Chattanooga, for example, which is perennially affected by flooding, average annual flood losses have been reduced to less than two percent of the losses that would have been suffered if the river system had not been regulated. The estimate of accumulated damages averted at Chattanooga is over $2.62 billion. Table 12-6 summarizes flood reductions at Chattanooga since 1936. Elsewhere in the Tennessee Valley, prevented damages have risen to approximately $262 million, and outside the Valley — on the lower Ohio and Mississippi Rivers — to nearly $137 million. Table 12-7 totals the damages prevented along the Ohio and Mississippi rivers as a result of TVA dams and reservoirs. In addition, the TVA reservoir system reduces flood heights along Mississippi River levees that protect six million acres of productive land, and it is estimated that the reservoir system increases the value of that land by $150 million (Tennessee Valley Authority, 1988).

Table 12-6. Benefits from Tennessee Valley Authority Flood Reduction at Chattanooga, Tennessee Since 1936.*

	STAGE IN FEET				
DATE	ACTUAL	COMPUTED NATURAL	REDUCTION	ACTUAL DAMAGES	DAMAGES PREVENTED
March 1936	37.1	41.3	4.2	$ 175,000	$ 2,100,000
January 1937	33.0	35.8	2.8	3,000	29,000
February 1939	31.7	33.3	1.6	2,000	30,000
December 1942	35.8	39.7	3.9	108,000	1,582,000
March 1944	31.7	37.8	6.1	2,000	702,000
January 1946	35.7	45.8	10.1	190,000	11,948,000
January 1947	31.9	44.5	12.6	8,000	10,092,000
February 1948	33.8	44.3	10.5	71,000	10,929,000
January 1949	29.5	36.3	6.8	0	1,113,000
February 1950	28.4	39.6	11.2	0	3,125,000
March 1951	25.8	35.6	9.8	0	440,000
January 1954	29.8	41.4	12.2	0	7,100,000
March 1955	22.5	35.0	13.3	0	390,000
February 1956	27.4	32.2	4.8	0	25,000
April 1956	17.8	34.0	16.2	0	200,000
February 1957	32.2	54.0	21.8	31,000	111,969,000
November 1957	29.6	36.8	7.2	0	2,150,000
February 1961	27.7	36.4	8.7	0	2,950,000
February 1962	29.0	39.0	10.0	0	27,495,000
March 1963	32.6	48.3	15.7	50,000	115,950,000
April 1964	22.7	34.7	12.0	0	1,505,000
March 1965	28.4	42.9	14.5	0	47,000,000
February 1966	20.6	34.4	13.8	0	1,750,000
February 1969	23.2	32.4	9.2	0	60,000
December 1969	28.5	39.0	10.5	0	34,500,000
December 1972	26.7	37.1	10.4	0	24,500,000
March 1973	36.9	52.4	15.5	**35,000,000	465,000,000
May 1973	29.1	35.7	6.6	0	14,000,000
January 1974	27.8	37.1	9.3	0	53,207,000
March 1975	25.6	43.8	18.2	0	216,000,000
April 1977	28.4	49.0	20.6	0	510,000,000
March 1979	25.8	34.7	9.1	0	20,002,000
March 1980	27.0	41.3	14.3	0	206,000,000
January 1982	20.6	33.7	13.1	0	12,520,000
April 1983	19.3	32.7	13.4	0	6,068,000
May 1984	34.8	51.0	16.2	3,400,000	700,000,000
			TOTAL	$39,040,000	$2,622,431,000

* Omits minor floods (under 32ft. natural) and secondary crests in same flood period.

** Includes $12,000,000 damages incurred by South Chickamauga Creek headwater flooding.

NOTE: Actual and prevented damages for floods beginning in 1963 are based upon projected developments as judged from actual surveys in 1938, 1948, 1953, 1961, and 1978.

Source: Tennessee Valley Authority, December 1988.

Table 12-7. Stage Reduction at Cairo, Illinois, and Prevented Flood Damages Along the Ohio and Mississippi Rivers Resulting From Tennessee Valley Authority Dams and Reservoirs.

		CAIRO STAGE (Feet)*			
YEAR	MONTH	ACTUAL	WITHOUT TENN. RIVER REGULATION	REDUCTION (Feet)	DAMAGES PREVENTED**
1945	Mid-March	53.92	55.4	1.48	$ 970,000
1946	January	52.13	53.5	1.37	500,000
1947	April	47.12	48.0	0.88	480,000
1948	April	51.6	53.4	1.8	1,600,000
1949	January	50.7	51.3	0.6	200,000
1950	January	55.35	57.2	1.85	1,800,000
1951	February	49.02	49.0	0	0
1952	March	50.7	51.2	0.5	400,000
1953	None				
1954	None				
1955	March	50.1	50.9	0.8	580,000
1956	February	43.7	45.8	2.1	700,000
1957	February	45.7	47.2	1.5	4,870,000
1958	May	43.1	46.2	3.1	8,000,000
1959	February	40.3	41.6	1.3	590,000
1960	April	47.4	50.1	2.7	4,500,000
1961	May	54.5	55.0	0.5	4,150,000
1962	March	50.5	51.7	1.2	2,530,000
1963	March	51.5	53.9	2.4	4,010,000
1964	March	48.2	50.4	2.2	3,250,000
1965	April	47.4	50.5	3.1	1,150,000
1966	February	41.9	43.2	1.3	634,000
1967	May	43.6	45.3	1.7	1,017,000
1968	June	43.9	45.5	1.6	1,402,000
1969	February	47.4	47.7	0.3	337,000
1970	May	49.1	51.5	2.4	1,844,000
1971	March	47.9	49.0	1.1	237,000
1972	April	49.1	51.6	2.5	3,091,000
1973	April	55.7	57.8	2.1	15,299,000
1974	February	52.2	53.1	0.9	7,358,300
1975	April	56.4	57.3	0.9	8,227,000
1976	February	42.0	42.8	0.8	142,000
1977	April	41.4	44.1	2.7	515,000
1978	March	50.7	51.9	1.2	8,926,000
1979	April	54.6	55.8	1.2	24,612,000
1980	April	48.3	50.5	2.2	4,404,000
1981	June	39.0	39.2	0.2	178,000
1982	March	47.8	49.5	1.7	1,779,000
1983	May	54.2	56.2	2.0	12,328,000
1984	May	54.0	54.1	0.1	48,000
1985	March	49.2	49.8	0.6	4,730,000
1986	December	41.4	42.2	0.8	0
1987	April	42.1	44.3	2.2	$ 42,000
				TOTAL:	$136,890,300

* Flood stage is 40 feet.
* Damage prevented in all flood during the year. Determined by the U.S. Army Corps of Engineers since 1965.

NOTE: Stage data shown are for the maximum flood without Tennessee River regulation in each year.

Source: Tennessee Valley Authority, December 1988.

DAM SAFETY

The impoundment of water is never without risk. Millions of people live and work in thousands of communities downstream of dams, and no matter how safely a dam is designed, constructed and maintained, the threat of failure due to structural deficiencies, earthquakes or sabotage remains. When a dam fails, the unexpectedness and high velocity of the escaping water can cause severe damage. Once signs of dam failure become visible, breaching often occurs within hours and there is limited time for evacuation.

There are a number of factors that affect the hazard classifications of the Nation's dams. For example, the availability of water, power, and/or recreational opportunities associated with dams often attracts new development. As a result, if adequate land-use regulations are not in place, development can encroach onto the floodplain and over time increase downstream vulnerability in areas protected by dams. Also, misconceptions or lack of understanding regarding dams can create a false sense of security, and reservoir sedimentation can significantly reduce flood control capacity. Competing reservoir uses can impair flood control functions, as irrigation interests, manufacturers, homeowners, and others relying on the dam for recreation and water supply often press for continued high water levels. As a result, little or no reservoir storage space may remain for flood control. In addition, the majority of dams are not designed to provide flood control, although there is often an impression that the control exists.

Hazard Classification

Classification of the hazard potential of a dam is based on the severity of the potential impact of dam failure rather than the dam's structural safety. Dams may be of sound construction and classified as "high hazard" if failure could result in catastrophic loss of life. Lower risk classifications include dams that pose a "significant hazard" if it is estimated that failure would result in large property loss, and "low hazard" dams that pose a risk of only minimal property loss if they fail (U.S. Army Corps of Engineers, 1982). Table 12-8 shows the criteria developed by the Corps of Engineers for classifying dam hazard potential. This classification scheme, or some modification of it, is used by most federal agencies and many states.

Federal Activities for Dam Safety

The failure of several dams during the 1970s led to a flurry of efforts to evaluate unsafe dams in the United States. The February 1972 failure of a coal mine waste impoundment at Buffalo Creek, West Virginia resulted in the loss of 125 lives and was largely responsible for passage of the National Dam Inspection Act (P.L. 92-367). This Act authorized the Corps to inventory and inspect nonfederal dams. Adequate funding for dam inspections, however, was not provided until 1976. Following failure of the Teton Dam in June of 1976, President Carter (on April 23, 1977) directed federal agencies to review their dam safety practices. An ad hoc interagency committee was established to coordinate dam safety programs and propose federal dam safety guidelines. In June 1979, the *Federal Guidelines for Dam Safety* was issued, and a Presidential memorandum directed each federal department and agency responsible for dam safety to adopt and implement the new guidelines (Committee on the Safety of Nonfederal Dams, 1982). Also in 1979, the executive order creating the Federal Emergency Management Agency designated the Director of FEMA as coordinator of federal activities to enhance dam safety. The activities and responsibilities of federal agencies with major dam safety responsibilities are reviewed below and summarized in Table 12-9.

Table 12-8. Hazard Potential Classification for Dams.

	HAZARD POTENTIAL CLASSIFICATION	
CATEGORY	LOSS OF LIFE (EXTENT OF DEVELOPMENT)	ECONOMIC LOSS (EXTENT OF DEVELOPMENT)
Low	None expected (No permanent structures for human habitation)	Minimal (Undeveloped to occasional structures or agriculture)
Significant	Few (No urban developments and no more than a small number of inhabitable structures)	Appreciable (Notable industry or structures)
High	More than a few	Excessive (Extensive community, industry or agriculture)

Source: U.S. Army Corps of Engineers. National Program of Inspection of Non-Federal Dams, 1982.

- **Corps of Engineers.** The Corps has some level of responsibility for five categories of dams: 1) dams planned, designed, constructed, and operated by the Corps; 2) dams designed and constructed by the Corps, but operated and maintained by others; 3) dams providing flood control storage at federal expense but which are owned by other agencies; 4) dams permitted/regulated by the Corps; and 5) dams inventoried and inspected by the Corps in accordance with the National Dam Inspection Act and the Dam Safety Act of 1986 (P.L. 99-662).

  In 1975 the Corps published the *National Program of Inspection of Dams*, which consisted of an inventory of dams, a survey of state capabilities in dam safety, "Recommended Guidelines for Safety Inspection of Dams," and recommendations for a national dam safety program (Duscha, 1982). Public Law 92-367 directed the Corps to undertake a national program to inventory and inspect nonfederal dams that might pose a hazard because of their locations in vulnerable or populated areas. The Corps completed the inventory in 1982, and listed over 68,000 dams, including almost 9,000 "high-hazard" dams. About one-third (2,884) of the high hazard dams were evaluated as "unsafe," due primarily to inadequate spillway capacity (Federal Emergency Management Agency, 1985).

Table 12-9. Federal Responsibilities for Existing Dams.

DEPARTMENT	DAM INVENTORY				PERIODIC INSPECTIONS CONDUCTED				DAMS UNDER FURTHER INVEST. & STUDY		DAM SAFETY MODIFICATIONS		DAMS WITH EAP - BY HAZ. CLASSIF.	
AGENCY	TOTAL	HAZARD CLASSIF.			TOTAL	SINCE LAST REPORT			COMPL. SINCE LAST REPORT	IN PROGRESS	COMPL. SINCE LAST REPORT	IN PROGRESS		
		HIGH	SIG.	LOW		FORMAL	INTER.	DURING					HIGH	SIG.
USDA TOTAL	28,127a	2,391	2,985	22,290	11,960	1,600	10,072	288	357	179	57	63	810	240
ARS	1	0	1	0	0	0	0	0	0	0	0	0	0	0
FmHA	78b	4	7	10	unk e	unk	unk	unk	unk	unk	unk	unk	unk	unk
FS	3,361	560	985	1,816	379	80	291	8	18	64	23	28	483	190
REA	29c	0	0	0	unk e	unk	unk	unk	unk	unk	unk	unk	unk	unk
SCS	24,658d	1,827	1,992	20,464	11,581	1,520	9,781	280	339	115	34	35	327	50
DOD TOTAL	810	451	64	295	583	266	312	5	23	48	17	14	404	22
Corps	560	412	30	118	579	266	309	4	21	48	17	14	402	22
Army	213	39	29	145	0	0	0	0	0	0	0	0	2	0
Navy	16	0	3	13	2	0	2	0	0	0	0	0	0	0
Air Force	21	0	2	19	2	0	1	1	2	0	0	0	0	0
DOE TOTAL	10	0	3	8	92	3	37		1	1				1
APA	2	0	1	1	1	0	1	0	1	1	0	0	0	0
RL	0	0	0	1	52		NA	NA					NA	NA
RF	6	0	1	5	2f	0	2	NA	0	0	0	0	0	1
SR	2	0	1	1	37	3	34	NA	0	0	0	0	0	g
DOI TOTAL	1,925	269	128	1,528	667	124	538	5	134	182	19	69	216	87
BOR	282h	214	48	20	163	2	161	0	60	111	4	32	200	45
BLM	917i	1	16j	900	261	10	251	0	0	0	1	0	1	8
BIA	300	37	24	239	69	1	68	0	0	0	0	0	0	0
FWS	155	9	19	127	144	86	58	0	4	2	9	8	9	17
NPS	271	8	21	242	30	25k	0	5	70	69	5	29	6	17
FERC	2,082l	548	250	1,278	3,239	151	2,170	918	256	141	51	101	525	241m
IBWC	8	4	0	4	18	4	14	0	0	0	0	0	2	0
MSHA TOTAL	1,386n	266	253	801	270	0	270	0	245	66	0	0	0	0
COAL	827n	229	218	314	270	0o	270	0	245	66	0	0	0	0
M/NW	559	37	35	487	0	0p	0	0	0	0	0	0	0	0
NRC TOTAL	27				33	0	33	0	0	0	0	0	0	0
NRR	19				5	0	5	0	0	0	0	0	0	0
NMSS	8				28	0	28	0	0	0	0	0	0	0
TVA	53	31	14	8	1,223q	111	25	0	4	5	5	2	31	14

a. Includes 461 dams whose classification is unknown.
b. Includes 57 dams whose classification is unknown. Agency is taking action to obtain current hazard classifications.
c. Includes 29 dams whose classification is unknown. Agency is taking action to obtain current hazard classifications.
d. Includes 375 dams whose classification is unknown. Most are expected to be low hazard, but their current classification has not been verified by actual field checks.
e. FmHA and REA are working with owners to obtain current data.
f. Annual intermediate inspections: one by USACE and one by the State of Colorado.
g. Engineering is in the process of developing a formal plan.
h. Dams examined and classified under the BOR Safety Evaluation of Existing Dams (SEED) Program.
i. Approximately 850 more structures exist that have not been evaluated or added to the BLM inventory. The majority of those dams barely meet the Guidelines' size criteria and are expected to be low hazard.
j. Hazard ratings for eight of these structures are being re-evaluated.
k. This figure represents both high- and significant-hazard dams.
l. Includes 171 dams not constructed and 12 dams under construction. Hazard classification not established for six dams under current applications for license.
m. Additional EAP's for 209 low-hazard dams.
n. Includes 66 dams not assigned a hazard classification.
o. Dams under major construction are inspected on a monthly basis.
p. All dams are inspected four times yearly for underground mines and twice yearly for surface mines.
q. Includes approximately 1,000 monthly field inspections and 87 special inspectors.

* All figures for this chart were provided by the individual agencies.

Source:

Federal Emergency Management Agency. National Dam Safety Program: A Progress Report. Volume 1. FEMA 195, July 1990.

- **Federal Emergency Management Agency.** Upon its creation in 1979, FEMA was given a responsibility to coordinate dam safety. In this capacity, FEMA coordinates the national dam safety program and reports progress to the President; chairs the Interagency Committee on Dam Safety; encourages the development and use of uniform guidelines and standards; coordinates dam safety research; coordinates the development and funding of training materials; facilitates information exchange among federal and state officials; encourages the use of model state legislation and programs; and encourages the use of model programs for preparedness, warning and evacuation (Tschantz, 1982).

- **Bureau of Reclamation.** The BOR is the coordinating agency for dam safety within the Department of Interior (DOI). In addition to responsibility for the safety of its own dams, it provides standards and guidelines for the safety of dams owned or operated by seven other DOI agencies.

  With respect to its own dams, the BOR has undertaken a "Safety Evaluation of Existing Dams" program. Activities of this program include: the preparation of emergency preparedness plans and inundation maps for downstream areas; structural modification of unsafe dams in some instances; and independent technical review of new dam design and construction. For other DOI agencies, the BOR provides: standards for design, construction, operation and maintenance; a dam inventory data base; and other program and technical services, including staff training (Parrett, 1982).

- **Tennessee Valley Authority.** The TVA has complete responsibility for the planning, design, construction, operation, and maintenance of all its dams. The TVA's responsibilities with regard to dam safety differ from those of other federal agencies in that: 1) the TVA constructs its dams with its own resources; and 2) all except one of its dams are located in a single river basin and operated and maintained for the unified development and regulation of the Tennessee River system. In addition, the TVA forecasts and schedules the flow of four privately owned large dams, and schedules hydroelectric production of eight Corps of Engineers' dams in the Cumberland River basin.

  As a result of a review of all its dams, the TVA identified 22 dams for possible modification to meet safety-related criteria for new dams. All of these identified dams are categorized by the TVA as requiring nonemergency corrective action.

  The TVA has developed and is implementing a comprehensive program to help ensure the structural integrity of its dams for the protection and enhancement of the water resources system and the well-being of the people in the Tennessee Valley region. This program consists of 1) ongoing inspection, operation, and maintenance; 2) study of existing TVA dams in light of modern dam design criteria and, if indicated, performance of rehabilitation work to bring the dams up to present-day standards; 3) management of emergencies; and 4) preparation and maintenance of emergency action plans that provide the basis for local, state, and regional emergency management agencies to develop their plans to cope with dam safety emergencies (Tennessee Valley Authority, 1989).

- **Department of Agriculture.** The Department of Agriculture (USDA), in fulfilling its responsibilities with regard to the maintenance and improvement of American agriculture, has a major involvement with dams. The USDA permits, owns, manages, plans, designs, constructs, finances, and grants dams. Most of these dams are small, but a few range up to about 200 feet in height.

A Dam Safety Committee, chaired by an Assistant Secretary of Agriculture, coordinates dam safety activities within the USDA. The Dam Safety Officer of the SCS serves as Executive Secretary of the Committee. Within the USDA, the Soil Conservation Service, Forest Service, and several other agencies also have roles and responsibilities pertaining to dams.

- THE SOIL CONSERVATION SERVICE. The SCS has provided technical and/or financial assistance for the installation of over 25,000 dams. Almost all of these are nonfederal dams, and ownership rests with state agencies, local conservation groups, cities or towns, and individuals. Most of the SCS-assisted dams are small, in the 25-60 foot height range, but several are over 100 feet high. The SCS is responsible for the design assistance it provides, and when federal financial assistance is provided, is also responsible for construction inspection. The SCS can provide some technical assistance for operation and maintenance (O&M), but O&M responsibility rests with the owner.

- THE FOREST SERVICE. The Forest Service (FS) owns 1,316 dams and administers permits for an additional 2,366 dams. Most of the dams owned by the Forest Service are designed and constructed by the FS in conjunction with the management of national forests and grasslands. The permitted dams are operated by other groups or individuals on FS-administered land. The FS maintains a staff of engineers trained in the design, construction, and maintenance of dams.

- THE FARMERS HOME ADMINISTRATION, RURAL ELECTRIFICATION ADMINISTRATION, AND THE AGRICULTURAL RESEARCH SERVICE. These agencies serve on the USDA's Dam Safety Committee and have some involvement with dams, but they generally depend on the SCS for technical assistance.

- **Federal Energy Regulatory Commission.** The 1920 Federal Power Act authorizes the Federal Energy Regulatory Commission (FERC) to regulate and license nonfederal hydropower developments. The Act requires that all licensed projects be safe, adequate, and best adapted to a comprehensive plan for development of river basins. FERC is currently responsible for the safety of about 2,000 nonfederal hydropower dams, and the Department of Energy (DOE) has asked FERC to be responsible for dam safety review on 20 DOE dams.

  As required by Section 10(c) of the Federal Power Act, FERC has developed a dam safety program to ensure that licensed hydro projects are adequately constructed, operated, and maintained for the protection of life, health, and property. No failures of dams licensed by FERC have caused loss of life or significant property damage. FERC's dam safety program calls for:

  - Preconstruction approval of dam designs, plans, and specifications often utilizing an independent Board of Consultants.
  - Prelicense dam site inspection, periodic and special inspection during construction, and periodic inspections during project operation, every one to three years, depending on project sites and potential hazards.

- Safety inspections and analysis of dams, every five years, conducted by an independent consulting engineer, employed by the licensee or exemptee, and approved by FERC.
- Emergency action plans to provide early warning to persons who might be affected by a project emergency.
- Periodic tests of the emergency action plan.

- **Other Federal Agencies.** Other federal agencies involved with dam safety include the Federal Coordinating Council for Science, Engineering and Technology (FCCSET) which reported on federal activities in *Improving Federal Dam Safety*, published in 1977, and the Office of Science and Technology Policy (OSTP) which published *Federal Guidelines for Dam Safety* in 1979 (Tschantz, 1982).

State and Local Activities for Dam Safety

The work of state dam safety agencies is vitally important for protecting the public from the hazards of unsafe dams. More than 95 percent of the approximately 80,000 dams in the United States meeting the size criteria used in the National Dam Inspection Program are owned by state governments, municipalities, watershed districts, industries, lake associations, developers, and private citizens (Federal Emergency Management Agency, 1990).

The first regulation of dams by state authorities apparently resulted from the construction of dams to harness water power. State regulation of dams in the 20th century is generally considered to have started in California after the failure of the St. Francis Dam in 1928. California law pertaining to dam safety has been strengthened at least twice following other major dam failures or near-failures (Federal Emergency Management Agency, 1988).

In 1970, the U.S. Committee on Large Dams (USCOLD)[2] used the California state law as the basis to prepare model state legislation (*Model Law for State Supervision of Safety of Dams and Reservoirs*) for the regulation of nonfederal dams. The model legislation describes five major functions that should be carried out relative to dam safety:

1) Review and approve plans for dams;
2) Inspect dams during construction;
3) Certify approval of new dams;
4) Inspect dams at least every five years; and
5) Take necessary actions to ensure maintenance of dams.

Other states were slow in following California's lead for dam regulation, and by the mid-1970s, only about half the states had established some form of dam safety program. During the 1980s, however, state dam safety initiatives increased. In 1986, the Association of State Dam Safety Officials (ASDSO) developed the *Model State Dam Safety Program* (Association of State Dam Safety Officials, 1987). As of 1989, 31 states had statutory authority to perform all five of the major functions listed above, compared with 24 states in 1982. In 1989, two states — Alabama and Delaware — had no statutory authority in any of these areas (Federal Emergency Management Agency, 1989).

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2 USCOLD is a professional society composed of engineers and others involved with large dam engineering.

A 1989 survey (Tschantz, 1990) examined several aspects of state dam safety programs, noting changes from a similar survey conducted in 1985. Aspects examined were: statutory authorities for regulating dams; funding resources and personnel for implementing dam safety responsibilities; inventories of regulated dams, unsafe dams, and high-hazard dams; and policies for classifying dams and specifying spillway design floods.

Table 12-10 shows the results of this survey regarding state dam safety statutory or regulatory authority in 1989. The survey indicated that 19 states did not have adequate statutory authority to conduct effective dam safety programs. Of the 31 states with adequate statutory authority, two had no program budget. State compliance with the FEMA/ASDSO Model State Dam Safety Program appeared to be mixed, and significant gaps existed among most states with regard to legislative/regulatory authority, and permitting and inspection activities.

Data from forty-four states indicated a collective 1989 budget designated for dam safety of $17,668,552, with a median budget of $250,000. The average state budget of $401,558 had increased from a 1985 average of $315,448. Forty-six states reported at least one full-time equivalent (FTE) personnel position with dam safety responsibilities. The total number of personnel available to all 46 states was 389 FTE, an increase of 30 percent from the 1985 45-state total of 324. States generally rated themselves fair to poor in terms of training and educating their own staffs and promoting public awareness and educating dam owners.

Some states do not maintain dam inventories, and there are wide differences among states regarding what constitutes a dam, which dams should be regulated or exempted from regulation, and how to define an unsafe dam. Forty-five states reported 1,550 unsafe dams remaining from the 1977-1981 Corps inspection program; five states did not know or report how many of these dams were still unsafe.

Private Sector Activities

Several private organizations are concerned with dam safety issues. The U.S. Committee on Large Dams, in addition to developing model state legislation for dam safety, has also participated in a number of other dam safety activities. The Interstate Conference on Water Policy (ICWP), while addressing a wide range of water policy issues, also provides important support for effective dam safety programs at both the federal and state levels.

A major private organization concerned with dam safety is the Association of State Dam Safety Officials (ASDSO) which was organized in 1984 to:

- provide a forum for the exchange of ideas and experiences in state dam safety programs and issues;
- foster interstate cooperation;
- provide information and assistance to state dam safety programs;
- provide representation of state interests before Congress and federal agencies responsible for dam safety; and
- improve efficiency and effectiveness of state dam safety programs.

Table 12-10. Summary of 1989 State Dam Safety Statutory or Regulatory Authority.

STATE	REVIEWS & APPROVES PLANS	INSPECTS DURING CONSTRUCTION	ISSUES PERMIT TO IMPOUND	PERIODICALLY INSPECTS	REQUIRES REMEDIAL WORK	ADOPTS RULES & REGULATIONS	REQUIRES FEE OR BOND	REQUIRES EAP
Alabama	NO c	NO	NO	NO	NO	NO	NO	NO c
Alaska	YES	YES	YES	YES	YES	YES	NO	YES
Arizona	YES	YES	YES	YES	YES	YES	YES c	YES c
Arkansas	YES	YES c	NO c	YES	YES	YES	YES c	YES c
California	YES c	YES c	YES c	YES c	YES c	YES c	YES c	NO
Colorado	YES	YES	YES c	YES c	YES	YES c	NO c	YES c
Connecticut	NO	YES	YES c	YES c	YES	YES	NO	YES
Delaware	NO	NO	NO	NO	NO	NO	NO	YES c
Florida	YES c	YES	YES	YES	YES	YES	NO	NO
Georgia*	YES c	YES c	NO c	YES c	YES c	YES	NO	NO c
Hawaii	YES	YES	NO	YES	YES	YES	NO	YES
Idaho	YES	YES	YES	YES c	YES	YES c	YES c	YES c
Illinois	YES	YES	YES	YES	YES	YES	YES c	YES
Indiana	YES c	YES c	NO c	YES c	YES c	YES c	NO c	NO c
Iowa	YES	YES c	NO c	NO c	YES	YES	YES c	YES c
Kansas	YES c	YES c	YES c	YES c	YES	YES	NO c	YES c
Kentucky	YES	YES	YES	YES	YES	YES	NO	NO
Louisiana	YES	YES	YES	YES	YES	YES	NO cc	YES
Maine	NO c	NO	NO	NO	YES c	YES	NO c	YES cc
Maryland	YES	YES	YES c	YES	YES	YES	YES	YES c
Massachusetts	YES	YES	NO c	YES c	YES	YES c	YES c	YES c
Michigan	YES cc	NO c	NO	NO	YES c	YES	NO	NO
Minnesota	YES	YES	NO c	YES	YES	YES	NO	YES c
Mississippi	YES	NO	YES	YES c	YES	YES	NO	NO
Missouri	YES c	YES c	YES c	YES c	YES c	YES c	NO	YES c
Montana	YES c	YES c	YES c	YES c	YES c	YES c	YES c	YES c
Nebraska	YES	YES	NO c	YES c	YES	YES	YES c	YES c
Nevada	YES	YES	YES	YES	YES c	YES	NO	YES
New Hampshire	YES	YES	YES c	YES	YES	YES	YES	YES c
New Jersey	YES	YES	YES	YES	YES	YES	NO	YES
New Mexico	YES	YES	YES	YES c	YES	YES c	YES c	NO c
New York	YES	YES c	YES c	YES	YES	YES	NO	NO c
North Carolina	YES	YES	YES c	YES c	YES	YES	NO	YES c
North Dakota	YES c	YES	YES	YES c	YES	YES	NO c	NO
Ohio	YES	YES	YES c	YES	YES	YES	YES	YES
Oklahoma	YES	YES c	YES	YES c	YES	YES	YES	YES c
Oregon	YES	YES	NO	YES	YES	YES	NO	NO
Pennsylvania	YES	YES	YES c	YES	YES	YES	YES c	YES c
Rhode Island	YES	YES	NO	YES	YES c	NO cc	NO	NO c
South Carolina	YES	YES	YES	YES	YES	YES	NO	NO c
South Dakota	YES	YES c	YES	YES	YES	YES	YES c	YES c
Tennessee	YES	YES	YES	YES	YES	YES	YES	NO c
Texas	YES c	YES c	NO c	YES c	YES	YES	NO	NO c
Utah	YES	YES	YES c	YES	YES	YES	YES c	NO
Vermont	YES c	NO c	YES c	NO c	NO c	NO c	YES c	NO
Virginia	YES c	YES c	YES	YES c	YES	YES	NO	YES
Washington	YES	YES	YES c	YES c	YES	YES	NO	NO c
West Virginia	YES c	YES c	NO cc	NO c	YES cc	YES c	NO c	NO c
Wisconsin	YES c	YES c	NO	NO c	YES	YES	YES	YES c
Wyoming	YES	YES c	YES c	YES c	YES	YES c	NO c	YES c

NOTE: C Comment provided; see text [of source document].
CC No specific response; judgement made based on state's comments, consistent with other state responses.
* No survey response - Data based on interpretation of submitted statute and regulation information.

Source: Tschantz, Bruce A. 1989 Report on Review of State Non-Federal Dam Safety Programs. FEMA 188, January 1988.

The ASDSO has become a major influence for improving state regulation of dams. With considerable support from FEMA, the ASDSO has developed a strong program to help state dam safety agencies improve their efforts to protect the public from unsafe dams (Federal Emergency Management Agency, 1988).

DIKES / LEVEES / FLOODWALLS

Dikes,[3] including levees and floodwalls, are essentially dams erected generally parallel to a stream (rather than across its channel) or parallel to the shoreline of lakes, oceans, and other water bodies. A levee is typically constructed of earth, while a floodwall is usually of masonry or steel construction (Linsley, 1972).

Levees were probably the first structures built for flood control by European immigrants to North America. The first levee in the Mississippi Valley was constructed at New Orleans in 1717, and levees have been built and rebuilt along the Mississippi River ever since (Leopold, 1954).

Levees are linear structures extending from high ground along one side of a floodprone area to another area of high ground on the same side of the water body. Levees generally protect the area between the levee and high ground adjacent to the floodprone area. Ring levees, however, are built entirely within the floodprone area to protect the area inside the levee.

For stability, the bottom width of the levee is normally several times the levee height. This requires considerable land area and, as a result, masonry floodwalls are typically constructed in urban areas instead of earthen levees (Flood Loss Reduction Associates, 1981). A long levee system may actually include several segments of earthen levees and masonry floodwalls.

Levees and floodwalls should be planned, designed, and constructed to avoid problems with overtopping, erosion of the levee material, seepage through or under the levee, subsidence, and cracking. Design should also anticipate storm drainage accumulation behind the levee. Levees and floodwalls can be designed to protect relatively small areas, but they may create a false sense of security since the level of protection is limited. These structures may actually increase flood elevations on adjacent upstream and downstream properties by obstructing or accelerating flood flow and/or increasing flood peaks (California Department of Water Resources, 1984).

An estimated 25,000 miles of levees and floodwalls[4] have been built nationwide, and these structures are the most common type of flood control works. While levees and floodwalls are effective in reducing flood losses, results of the Corps' nonfederal dam inspection program suggest that a large

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3 "Dike" is a general term used to describe longitudinal structures that serve to retain water. Levees and floodwalls are both considered a type of dike. In this chapter the terms "levee" and "floodwall" are used instead of "dike."

4 In the course of work on the *Assessment Report*, no data were found to distinguish between miles of levees and miles of floodwalls constructed.

percentage of private or locally built levees and floodwalls provide a low level of protection or are poorly designed and maintained. Some privately built levees and floodwalls may have been constructed without regard to any design standards at all. Over time, a levee or floodwall's history — and its protective limitations — are easily forgotten. Maintenance, particularly of privately owned levees, is often inadequate. Levee or floodwall overtopping or failure is involved in approximately one-third of all flood disasters.

Levees and floodwalls provide only partial protection from flood problems for several reasons:

1) Many levees (including those built for emergency or agricultural purposes) are designed to provide protection only from smaller floods (e.g., 5- to 15-year flood frequencies) or were built immediately before or during a specific flood event.

2) Only a portion of all earthen levees built with crown elevations equal to the design flood elevation can provide the expected flood protection because of changing hydrologic conditions and the possibility of structural failure before overtopping.

3) Areas behind levees and floodwalls are often subject to severe internal drainage problems. The exclusion of floodwater also contributes to retention of stormwater runoff. Surfacing ground-water may be another problem.

Areas behind levees and floodwalls may be subject to greater than normal risk of flood damage for several reasons. For example, floodplain residents may believe they are protected from floods and do not feel it necessary to take proper precautions; development may continue or accelerate based on expected flood protection. A levee breach or floodwall failure, however, is similar to a dam break and can release flood waters with high velocity. After a breach, the downstream portion of the levee/floodwall system may also act as a dam, prolonging the flooding behind it (Federal Emergency Management Agency, 1987).

There is no national data base of information on the condition and safety of levees and floodwalls that covers all levels of government and classes of ownership (Schilling, 1987).

FEDERAL ACTIVITIES

The principal federal agencies with roles and responsibilities pertaining to levees and floodwalls are the Corps of Engineers, FEMA and the TVA.

Corps of Engineers

While the Corps maintains data on the Nation's flood control reservoirs, similar data are not collected for the other types of flood control structures such as levees, dikes and floodwalls (National Council on Public Works Improvements, 1988). The National Research Council reported that the Corps has designed and constructed about 10,500 miles of levees and floodwalls, most of which have been assigned to nonfederal sponsors for operation and maintenance (National Research Council, 1982).

Federal Emergency Management Agency

For purposes of making special flood hazard area determinations for the National Flood Insurance Program (NFIP), FEMA has established minimum design, operation, and maintenance standards for levees. FEMA accepts determinations by other federal agencies as to whether or not the levees designed, constructed, or inspected by those agencies meet one percent annual chance flood protection standards. Protected areas behind levees meeting such standards are shown as areas of moderate flood hazard (Zone B) on NFIP maps. Approximately 1,000 communities nationwide (or 5.5% of the communities identified as floodprone) have one or more levees credited on NFIP maps with providing one percent annual protection. The total length of these structures is approximately 9,000 miles and the structures protect approximately 5,000 square miles of land. The states of Arkansas, California, Louisiana, Mississippi, and Texas have the greatest number and length of levees providing one percent or greater protection (Mrazik, 1989).

Tennessee Valley Authority

The TVA owns and inspects 38 saddle dams and levees which are subject to the same criteria for inspections, instrumentation, and maintenance as are the TVA's regular dams (Tennessee Valley Authority, 1989).

STATE AND LOCAL ACTIVITIES

As shown in the last column of Table 12-1, 13 states have established special regulations pertaining to levees. Minnesota, for example, has established a requirement that all communities with emergency levees must prepare emergency response plans. The State of Washington provides grants to communities to help maintain levees and other flood protection projects.

CHANNEL ALTERATIONS

Channel alterations reduce flooding by increasing the flow-carrying capacity of a stream's channel. The various types of alterations include: straightening, deepening or widening the channel; removing debris; paving the channel; raising or enlarging bridges and culverts that restrict flow; and removing dams that interfere with flow. Underground conduits can also be installed to carry part or all of a small stream's flow.

All of these channel alterations contribute to reducing the height of a flood. It is sometimes possible, by extensively reconstructing a stream channel, to contain major floods within the channel banks. Unfortunately, such alterations sometimes result in increased downstream flooding by accelerating the flow of flood waters.

Channel deepening is not very well suited to major streams because sediments can quickly fill in the excavated area. Even on smaller streams, frequent dredging is often necessary to maintain a deeper channel. Care must also be taken to avoid causing erosion when changing a channel. Channel alteration can become a significant expense for local governments, and local maintenance of such channels is historically poor.

Channel alterations are similar to levees and floodwalls in that they can be used to protect a specific site or region. Channel alterations, however, are not subject to sudden or disastrous failure. Channel alterations for flood control can sometimes be used for other purposes such as navigation and recreation. Boat launching facilities, for example, can be included in projects to deepen a channel.

The environmental impact of altering a stream channel depends on the specific techniques used. Bridge and culvert reconstruction usually has only a temporary impact during construction. Widening, deepening, or paving of channels, however, may destroy fish and wildlife habitat and other natural resources for several years, decades, or perhaps even permanently (Flood Loss Reduction Associates, 1981).

FEDERAL ACTIVITIES

The Corps and the SCS are the two agencies that undertake the largest number of projects involving channel alterations. Corps projects are typically in larger streams and rivers, while SCS projects are mostly focused on smaller streams in the upper portions of watersheds. As of June 30, 1976 the SCS had provided assistance for the construction of 16,971 miles of open channels. Of these, 9,927 miles had been constructed under the Watershed Protection and Flood Prevention Program. (Buie, 1979).

Channel alterations are still an integral part of many flood control projects. Channel alterations may constitute an entire project, or may be included at sections along a stream as part of a more comprehensive project. In recent years, channel modification has decreased in use primarily because of concern over adverse environmental impacts. Alternative designs are frequently developed that include less straightening of channels, more gradual slopes, and use of natural vegetation or riprap rather than concrete-lined channels.

STATE AND LOCAL ACTIVITIES

Urban drainage systems have historically provided for the safe passage of storm flows through populated areas. The primary emphasis has been on efficient systems that rapidly convey storm runoff to downstream receiving waters. Achievement of efficient drainage has typically been accomplished through some form of channel modification involving widening, deepening and straightening of existing channels, and by creation of new channels, particularly drainage ditches or buried storm drains. Channel alteration is widely practiced by state and particularly local governments to control local flooding.

Historically, once runoff was transported out of populated areas and into a watercourse, the control of stormwater was considered complete. Until recently, the downstream impacts and the water quality impacts of urban drainage systems were often not fully considered. As urbanization accelerated, the concept of conveyance-oriented water management was reassessed. The development of upland areas produces increasing quantities of runoff, and culverts and drainage pipes that were once adequate have become unable to accommodate the increased volume of runoff generated. Localized flooding has become more prevalent, and the cost of installing larger pipes and culverts has often been prohibitive. Further, there is no guarantee that new channel modifications will be adequate under future development conditions. As a consequence, many state and local governments no longer rely strictly on channelization and rapid drainage. Instead, they have adopted a more balanced approach that incorporates stormwater storage (see section on Stormwater Management later in this chapter) with stormwater conveyance, as well as other measures to address the water quality of stormwater (Division of Water Resources, 1986).

HIGH FLOW DIVERSIONS

Diversions intercept flood flows upstream of a damage-prone or constricted area, and route flows around the area through an artificial channel or a designated flow-way. Diversions may either completely reroute a stream or they may collect and transport only those flows that: a) exceed the normal capacity of the channel; or b) would cause damage.

Diversions sometimes offer the advantage of protecting several nearby communities with one major facility. Negative aspects include the false sense of security that may prevail in the protected areas and lack of awareness that the floodway actually exists.

Diversions are particularly well suited for protecting developed areas because they do not require land acquisition or construction within the protected area. Opportunities for diversions, however, are often limited by local land formations and soil conditions. The receiving channel must have enough capacity to carry the flow conveyed through the diversion without causing flooding. Also, the use of diversions may be limited in some states by laws prohibiting transfer of water between basins or watersheds (Flood Loss Reduction Associates, 1981).

Examples of high flow diversions include several projects (often called floodways or spillways) along the Mississippi River. These include the New Madrid Floodway below Cairo, Illinois, the Morganza Floodway above Baton Rouge, Louisiana, and the Bonnet Carre Spillway above New Orleans. These types of high flow diversions are expensive and ordinarily used only for the protection of major urban areas (Linsley, 1972). A recent example described in Chapter 1 is the temporary diversion of excess water from the Great Salt Lake, Utah to an evaporation basin.

STORMWATER MANAGEMENT

Stormwater management has traditionally been primarily a local concern. State and federal government involvement has been typically limited to managing stormwater runoff from roadways. Stormwater management is now taking on more importance at the local level and receiving increased attention from state and federal governments. This newfound attention by federal and state governments is due in part to a natural expansion of more traditional flooding concerns, and to awareness that a large percentage of flood insurance claims are for areas not identified as floodplains.

Flooding can be increased significantly by the runoff from land that has been stripped of vegetation or covered with buildings, pavements, and other impervious materials. Historically, most communities sought to remove excess surface water following a rainfall from roadways, individual homesites, subdivisions, and other areas, and to confine and transport that water as quickly as possible. As urbanization has spread, this approach has contributed significantly to increased frequency of downstream flooding and/or the need to construct flood control structures. Reduced ground-water supplies and degraded water quality are frequent byproducts of this approach.

Today, runoff is often handled in a totally different manner than it was in the past. For example: runoff equivalent to a relatively high frequency storm (e.g., a 2- to 10-year event) may be detained or retained on-site through a variety of measures; excess runoff may be retained or detained within a regional system; total runoff within a watershed may be managed so that discharges from different sub-units reach the main channel at different times and reduce peak flows in downstream areas; and conveyance of stormwater is more likely to involve some type of natural drainage system rather than a concrete-lined channel or enclosed pipe.

The main objective of on-site detention is to prevent excessive runoff from developed areas. A secondary benefit is that on-site detention measures may be designed to trap pollutants, and may therefore improve water quality.

Use of on-site detention measures may be voluntary or required by regulatory programs. Regulations requiring on-site detention are often part of zoning or other broad programs controlling land-use and development in upland areas. Most on-site detention is for storm water runoff from storms of greater frequency that the one percent annual chance flood, and as a result, most stormwater detention measures typically provide little protection from the one percent flood.

On-site detention measures can include small ponds on land used for open space purposes. These ponds sometimes take the form of shallow grass-covered basins that can be used during dry periods as athletic fields, parking lots, or for other purposes. Detention basins are also sometimes created as a result of excavation during sand and gravel mining operations. Controls pertaining to the clearing of land and the amount of impervious area on a site are most applicable to sites under construction. In urban areas, on-site detention measures usually take the form of design provisions to slow runoff, and may include: equipping roofs or parking lots for temporarily storing at least a part of the water that falls on them; designing streets in hilly areas to prevent rapid runoff; incorporating small retention basins into landscaping; using rock-filled pits to catch gutter runoff; and using pavements that let water seep through into the ground below.

The cost of individual on-site detention measures is usually not high. The cost often falls on the owner of the land where flood waters arise, while most other flood control measures are paid for by those protected or by the general public.

On-site detention ponds or reservoirs can lose their effectiveness over time if they are not regularly cleaned and maintained, and cleaning and maintenance costs can be significant. Another potential problem with on-site detention measures is the lack of unified control over drainage patterns. This problem, however, can be handled through broad-scale planning of the overall system (Flood Loss Reduction Associates, 1981).

The use of detention basins as a type of structural flood control measure has greatly increased over the last 20 years. Many local ordinances now require "zero-increment" runoff for new development, and this means that on-site detention must be provided. In addition, guidelines on storm runoff and erosion and sediment control developed by the SCS and others place a strong emphasis on on-site detention. Extensive use of detention basins, however, may pose problems that are not yet fully evident. For example, provisions for maintenance are seldom included, particularly if responsibility for the detention basin is not transferred to a government unit.

Throughout the country there is now considerable interest in using natural wetlands to help manage stormwater runoff. Several research projects are being undertaken to evaluate the methods and wisdom of this approach to stormwater management. One point of view holds that natural wetlands are generally already heavily stressed, particularly in areas where stormwater management is a problem, and as a result stormwater should not be discharged to natural wetlands but used instead to help restore or create wetlands (Meagher, 1988).

FEDERAL ACTIVITIES

The principal federal activity pertaining to stormwater management is the Stormwater Discharge Permit Program of the Environmental Protection Agency (EPA). Section 405 of the Water Quality Act of 1987 (P.L. 100-4) gave the EPA broad authorities to regulate stormwater discharges. Over the next few years, major municipalities (with populations greater than 100,000) will participate in a permit program for stormwater discharges. This program will be similar to the current wastewater discharge permit program. After October 1, 1992, the stormwater discharge program will be expanded to include industries and smaller communities. A significant change is that with establishment of the Stormwater Discharge Permit Program, the water quality of stormwater discharge will be as important a consideration as its quantity (Meagher, 1988).

STATE AND LOCAL ACTIVITIES

Many urban communities have begun to recognize that a significant portion of their open space land provides stormwater management functions along with opportunities for urban recreation and wildlife protection. In addition, many of these same communities are recognizing that their costs associated with stormwater flooding damage and investment in costly channelization can be reduced through different approaches to stormwater management, including approaches that combine stormwater management with open space programs.

A nationwide survey of communities in 1983 showed only 39% with stormwater regulations in effect (Burby, 1985). The effectiveness of those programs, however, may be somewhat better than that statistic implies. In Arizona, for example, the larger, rapidly urbanizing communities all have some form of stormwater management requirement for new development. Although only 35% of the surveyed communities in Arizona have such regulations, all of the larger communities in the two urban counties that include 77% of the State's population regulate the development of watersheds (Bond, 1988).

Within the last few years, several stormwater management utilities have been organized in communities throughout the country. Many of these utilities have local taxing authority and assess property owners within the district to pay the costs of stormwater management.

SHORELINE PROTECTION

The United States has a total of 84,240 miles of shoreline, of which 3,680 (four percent) are along the Great Lakes. These shores encompass practically all known landforms and consist of materials of varying vulnerability to the coastal processes that flood and erode the shore. Damages from shore erosion include the loss of beaches for recreation; loss of waterfront land; damage to highways, residences, commercial development, and other waterfront structures; and loss of wetland and other environments important to marine and coastal life forms.

Among the most important issues facing coastal floodplain managers in the coming years are the issues relating to continued development of the coastal zone, the erosion of new and existing development, and the impacts of accelerated sea level rise.

The EPA and others have undertaken several research projects, including case studies, to examine the potential impacts of accelerated sea level rise. These studies have highlighted the potential risk to natural and man-made coastal features in addition to the obvious risks faced by structures built directly on the shore. For example, coastal wetlands may be lost if shoreline development prevents the inland migration of wetlands in response to sea level rise, or if sea level increases more rapidly than wetlands can adjust. Also, storm drainage systems (e.g., existing drainage outlets) may not be able to function properly, and inland flooding conditions may change with a change in sea level. In addition, water supplies may be endangered as rising sea levels cause salt water intrusion into aquifers and coastal rivers.

Assuming that sea level will continue to rise at an accelerated rate (regardless of what that rate is), coastal flooding and erosion will also accelerate, placing billions of dollars worth of additional coastal property at risk. Major questions facing coastal managers include whether or not to retreat from the shoreline, armor the shoreline, or provide for beach nourishment. The direction of future efforts to address rising sea level is currently unclear.

Many coastal geologists have joined to urge a strategic retreat from the coast. The National Park Service (NPS) has adopted a policy of allowing natural forces to act on the shoreline rather than attempt to prevent erosion through use of structural measures. The State of North Carolina has adopted a similar policy toward projects for erosion and flood control in the coastal area.

Some federal agencies have limited the use of structural measures on federal lands. The Coastal Barrier Resources Act prohibits most federal expenditures (including expenditures that could be used for structural erosion control measures) in "undeveloped" coastal regions. Where economically justifiable and environmentally acceptable, federal agencies still construct projects to protect existing development. Many states have also limited the use of structural controls in undeveloped or lightly developed areas, but continue to permit structural projects to protect existing development. Pressure from property owners and community leaders to protect existing investments in coastal areas has been, and is likely to continue to be, very strong.

Traditionally, historical hydrological data have been used to judge and evaluate the need for shoreline protection measures. It is beginning to appear, however, that current and projected future changes in climate are leading to environmental changes — particularly rising sea level — with at least three key water resources implications. First, shoreline protection problems associated with sea level rise are likely to become more significant relative to infrastructure policy. Second, existing hydrological data and analytic techniques may not be relevant to assessing future project needs. Third, climate changes or sea level rise may affect water resources in inland regions in ways that are not well understood today (Schilling, 1987).

SHORELINE PROTECTION METHODS

Measures used to protect the shoreline from flood and erosion processes include the use of nonstructural measures such as beach nourishment, and structural measures, designed to stabilize the shoreline.

Nonstructural Measures

When the natural protection system fails during large storms, the first solutions frequently chosen are quasi-natural methods such as beach nourishment or artificial sand dune building. Such solutions retain the beach as an effective wave energy dissipater and the dune as a flexible last line of defense. These methods, however, may provide only a temporary solution to chronic long-term erosion caused by a diminishing supply of sediment in the littoral system and by the slow rise of sea level.

When conditions are suitable, long reaches of shore may be protected by artificial beach nourishment at a relatively low cost per linear foot of protected shore. An equally important advantage is that artificial nourishment responds directly to the basic cause of most erosion problems — a deficiency in natural sand supply — and enhances rather than damages the adjacent shore. An added consideration is that a widened beach has added recreational value. Well-known beach nourishment projects include the 10.5-mile beach restoration in Dade County, Florida, including Miami Beach (U.S. Army Corps of Engineers, 1984), and the 26-mile long Harrison County "sand beach" in Harrison County, Mississippi.

Structural Measures

In general, structural measures designed to stabilize the shore fall into two classes: 1) structures such as breakwaters, seawalls, bulkheads, and revetments to prevent waves from reaching a harbor area; and 2) structures such as groins and jetties used to retard the longshore transport of sediment in the littoral zone. Groins and jetties may be used in conjunction with seawalls or beach fills or both.

Providing separate protection for short reaches (e.g., individual shorefront lots) within a larger zone of eroding shore, is difficult and costly. Such individual protection efforts often fail at their flanks as the adjacent unprotected shoreline continues to recede. Partial or inadequate protective measures may even accelerate erosion of the adjacent shores. Regional and coordinated action in accordance with a comprehensive plan that considers erosion processes over the larger zone of eroding shore is much more effective and economical.

Onshore structures such as bulkheads, seawalls, and revetments armor the shore and provide protection, based on their use and design, for backshore development or erodible bluffs. Shorefront owners often resort to "shore armoring" by constructing wave-resistent walls of various types when the economic or esthetic values of their properties are threatened.

Breakwaters can have beneficial as well as detrimental effects on the shore. All breakwaters reduce or eliminate wave action in their lee (shadow). Whether breakwaters are constructed as offshore, detached, or shore-connected structures, the reduction or elimination of wave action also reduces longshore sediment in the shadow.

Groins are barrier-type structures that extend from the backshore into the littoral zone. They are generally constructed in a series — referred to as a groin field or system — along the entire length of beach to be protected. The basic purpose of a groin is to modify the longshore movement of sand and to either accumulate sand on the shore or retard sand losses. Trapping of sand by a groin is accomplished at the expense of the adjacent down-drift shore unless the groin or groin system is artificially filled with sand to its entrapment capacity. To reduce the potential for erosion damage to property down-drift of a groin, some limitation must be imposed on the amount of sand permitted to be impounded on the up-drift side. Since more and more shores are being protected, and less and less sand is available as natural supply, it is now desirable, and frequently necessary, to place sand artificially in the area between the groins, thereby ensuring an uninterrupted passage of the sand to the down-drift beaches.

Jetties are structures used at inlets to stabilize the position of the navigation channel, shield vessels from wave forces, and control the movement of sand along the adjacent beaches so as to minimize the movement of sand into the channel. Like the groin, the jetty's major adverse impact is the erosion of the down-drift beach (U.S. Army Corps of Engineers, 1984).

FEDERAL ACTIVITIES

The Corps of Engineers is the federal agency most directly involved with shoreline protection methods. The Corps' authority to participate in shoreline protection projects began with legislation enacted in 1936. Under existing law, however, federal funds may not be used to protect private land unless there is a significant public benefit. Upon request, the Corps may provide technical guidance and planning assistance to help local interests handle shoreline problems.

The Corps cannot construct any shoreline protection project without Congressional approval, with the exception of projects authorized by the Corps' Small Projects Program. This program authority allows the Corps to participate in the construction of a shore protection project when the federal cost does not exceed $2,000,000. Congressional approval is required for specific beach erosion control projects that would have an estimated federal cost greater than $2,000,000. Beach erosion control projects may be authorized individually or may be part of multi-purpose projects that include shoreline protection objectives. Data on the costs of shoreline protection are summarized below:

- As of June 1985, the total investment, both federal and nonfederal for all shoreline protection studies and projects, regardless of status or purpose, was calculated as $360.1 million. This total represents the financial investment in 404 shoreline protection projects, including 124 Beach Erosion Control Projects for which Congress has authorized construction on 336.3 miles of shoreline. Of the $360.1 million, 38 percent or $138.5 million has been federal funds. The total federal investment in the 124 authorized Beach Erosion Control Projects was $138.5 million of a total planned federal expenditure of $541.4 million (see Table 12-11).
- As of 1983, 57 of the authorized Beach Erosion Control Projects had been completed and 10 were under construction. The completed projects, protecting 89.9 miles of shoreline, had been constructed at a total cost of $45.3 million, of which 42 percent ($19.1 million) was federal funds (see Table 12-12) (Schilling, 1987).

STATE AND LOCAL ACTIVITIES

Most coastal states have historically participated in structural and nonstructural projects for shoreline protection. Because of the high cost of most structural projects, only a limited number of these have been undertaken without federal assistance. Some states, notably North Carolina, have adopted policies against new structural shoreline protection projects, opting instead to allow the shoreline to retreat naturally. Other states, such as Connecticut, have adopted policies that discourage construction of new structural projects, but do not specifically prohibit them. Still others, such as New Jersey, have active structural protection programs.

Federal funds cannot be applied to protect privately owned land unless significant public benefit can be demonstrated. Some states (e.g., Connecticut and Maryland), however, do offer funding assistance, and some states have empowered localities to establish Beach Protection Districts with the authority to collect taxes to fund long-term maintenance programs.

On the local level, communities may undertake structural shoreline protection measures, but these tend to be for relatively small projects. Few communities have the financial resources to undertake major shoreline protection projects without either state or federal assistance.

Table 12-11. Status of Federal Expenditures on Authorized Beach Erosion Control Projects.

PROJECT STATUS	NUMBER OF PROJECTS	FEDERAL COST ($000)	FEDERAL EXPENSE THRU 6/85 ($000)	BALANCE TO COMPLETE ($000)
Completed	62	35,091	35,091	0
Under Construction	23	438,852	98,762	340,090
Deferred	15	35,927	887	35,040
Inactive	14	31,506	3,713	27,793
TOTAL	124	541,376	138,453	402,923

(Data as of July 1985)

Source: Schilling, Kyle, and others. The Nation's Public Works: Report on Water Resources. Categories of Public Works Series. Washington, D.C.: National Council on Public Works Improvement, 1987.

Table 12-12. Total Federal and Nonfederal Investment in Beach Erosion Control Projects Completed or Under Construction.

PROJECT STATUS	TOTAL PROJECTS	NON-FEDERAL COST ($000)	FEDERAL COST ($000)	TOTAL COST ($000)	MILES PROTECTED
Completed	57	26,206	19,056	45,262	89.9
Under Construction	10	68,267	63,423	131,690	69.5
TOTAL	67	94,473	82,479	176,952	159.4

(Data as of 1983)

Source: Schilling, Kyle, and others. The Nation's Public Works: Report on Water Resources. Categories of Public Works Series. Washington, D.C.: National Council on Public Works Improvement, 1987.

PRIVATE SECTOR ACTIVITIES

Private land owners have also applied measures to forestall erosion and reduce damages. These measures are necessarily low-cost and small-scale, and include, for example, vegetation plantings, beach fill, breakwaters, groins, revetments, bulkheads, and seawalls. Typically, private landowners cannot expect their efforts to be successful in areas where wave heights in excess of six feet are common, or where severe storms are likely to occur each year (Schilling, 1987).

LAND TREATMENT MEASURES

Land treatment measures are used to reduce the runoff of water to streams or other areas. Techniques of land treatment include: maintenance of trees, shrubbery and vegetative cover; terracing; slope stabilization; grass waterways; contour plowing; and strip farming. These measures are intended to reduce water flow by improving infiltration of rainfall into the soil, thereby slowing and reducing runoff and reducing sedimentation that can clog stream channels or storage reservoirs. While the effect of any individual measure is small, extensive land treatment programs can effectively reduce flooding in small headwater areas. Land treatment measures are less effective in downstream areas subject to larger floods. In addition to reducing flooding, many land treatment measures may also reduce off-site pollution caused by the runoff of agricultural chemicals.

Land treatment measures are most commonly used in agricultural areas. In areas with steep slopes and unstable soils, maintaining a good growth of grass and other vegetation may be the most practical way to reduce runoff and erosion. Several land treatment measures involve little or no additional cost to the farmer, and some, such as "no-till" or minimum tillage practices, actually reduce farming costs. Land treatment measures may be undertaken as either a public or private effort. Efforts that require significant expenditures by the land-owner are frequently supported by technical and financial assistance from public sources, particularly programs of the U.S. Department of Agriculture (Flood Loss Reduction Associates, 1981). Land treatment measures are both structural and nonstructural.

STRUCTURAL MEASURES

Several land treatment measures to reduce runoff and erosion involve creation of structures to retain or redirect runoff. Terraces and diversion channels act on-site to limit runoff and reduce erosion, while sediment basins and grassed waterways trap sediment and promote infiltration of runoff after it leaves the site but before it reaches receiving waters (Clark, 1985).

Terraces

Terraces are among the oldest and most common soil erosion control practices, and are needed where other types of conservation practices are inadequate or inappropriate. The typical terrace is an earthen embankment, or a channel or combination of ridge and channel constructed across a slope. Terraces are used to intercept runoff before it can concentrate sufficiently to cause erosion, and then direct the runoff to a stable outlet. In so doing, terraces trap sediment and associated nutrients and pesticides that would otherwise reach watercourses. The trapped sediment can subsequently be redistributed over the land. As of 1977, terraces were in use on an estimated 31.3 million acres of land, and were being constructed on an average of 600,000 additional acres annually (Highfill, 1983).

Disadvantages of terraces include their relatively high costs, particularly the costs of initial construction, and complications that may be caused for farm management. Many terraces built in the past are now being removed from the land because they are incompatible with the large, heavy agricultural machinery now commonly used in the United States (Clark, 1985).

Diversion Channels

Diversion channels are vegetated channels constructed across the slope of a field to catch water and carry it off the field. They are relatively inexpensive to construct, but must be maintained regularly by mowing the vegetation and periodically removing accumulated sediments (Clark, 1985).

Control Basins

Control or sediment basins are generally used in fields where terraces are impractical because of the topography. Control basins are designed to control runoff of water and sediment, and are generally designed to accommodate a "10-year" frequency storm. Runoff must be released through infiltration or underground outlets (Highfill, 1983).

Grassed Waterways

Grassed waterways are natural or constructed channels lined with vegetation to prevent gully formation. They can be effective even on steep land, provided they are seeded with suitable grasses. As with diversion channels, grassed waterways may take some acreage out of crop production and interfere with large farm machinery (Clark, 1985).

NONSTRUCTURAL MEASURES

A variety of nonstructural measures can be used on agricultural land to reduce runoff and erosion. These include tillage practices, cropping patterns, and use of filter or buffer strips.

Tillage Practices

Tillage practices to reduce runoff and erosion include contouring and conservation tillage practices. Contouring involves plowing, planting, and harvesting along the contours of the land rather than up and down slopes. The furrows catch and hold water, reducing runoff by allowing it to infiltrate into the ground. Contouring is one of the most widely applied and longest used conservation techniques in the United States. As with some structural land treatment measures, however, recent increases in machinery size, farm size, and labor costs have reduced the frequency with which contouring is used (Clark, 1985).

Conservation tillage is a term applied to several practices that reduce soil cultivation and leave a protective vegetative layer on the surface. Although conservation tillage is a relatively new technique for modern agricultural practice, it has been estimated that about 24 percent of all U.S. cropland was in some form of conservation tillage in 1982 (Clark, 1985). The technique appears to be growing in popularity as its benefits, including lower economic costs and reduced runoff and erosion, are demonstrated. One disadvantage of conservation tillage is the need for increased herbicide applications to control weeds.

Cropping Patterns

The choice of cropping patterns may also have a significant impact on runoff and erosion, particularly when the choice is between row crops that leave large amounts of land uncovered and permit easy flow of water, and field crops that provide a soil cover and retard runoff. Crop rotation (e.g., periodically rotating row crops with field crops), cover cropping (planting a cover crop when land would otherwise be left fallow), and strip-cropping (planting alternate strips of row crops and grass in a field) are all methods that can be used to reduce runoff and erosion (Clark, 1985). Some farmers, however, in order to maintain their crop production acreage bases for participation in price support and other farm programs, may not have the flexibility to fully use these techniques.

Filter Strips

Filter (or buffer) strips are strips of grasses or other conservation vegetation planted along the downslope edges of cultivated fields or between fields and adjacent streams. Filter strips may also be used in nonagricultural settings to reduce runoff and sedimentation from highways, construction sites, and other areas subject to erosion.

SUMMARY AND CONCLUSIONS

During the first half of this century, flood control structures served as the primary — indeed, almost the only — means of addressing the Nation's flooding problems. Estimates, while not precise, indicate that the Nation's large investment in flood control structures has yielded major benefits in lives saved and damage prevented.

During the second half of the century, the number and size of new flood control projects has decreased for a variety of reasons. High construction costs coupled with increased cost-sharing requirements for nonfederal sponsors have contributed to the lower number of new projects. Also, structural measures have been criticized for causing destruction of riparian habitat and other environmental resources, creating potential for catastrophic damage in the event of structural failure, and inducing floodplain development. The eventual loss of flood storage capacity due to sedimentation, the need to maintain structures, and the length of time required to build federal projects are other concerns affecting the use of structural flood control measures. Furthermore, there is now greater recognition that humans can effectively adjust to floods as an alternative to trying to control flooding.

As the number of new flood control structures has slowed, the use of other floodplain management measures such as regulations, floodproofing, and warning systems has increased. It appears likely that, for the foreseeable future, the number of new flood control projects may hold steady or decrease further and that relatively few large flood control structures will be built. Nevertheless, increasing flood damages and concentrations of floodplain development indicate a continuing need for investment in structural flood control, along with nonstructural and compensation strategies. Flood control needs that can now be identified are more localized, with greater identifiable local benefits consistent with local and state construction, or larger nonfederal shares for projects with federal participation.

Local and private construction of relatively small structural flood control projects is certain to continue and may even increase. Detention and retention basins to regulate runoff from newly developed areas are being used with increasing frequency. Regional variation in use of detention/retention basins and other stormwater management measures is great. In some areas of the country, management techniques are employed on individual lots and small sub-watersheds. In other areas, regional solutions are routinely applied. Achieving effective stormwater management — rather than simply stormwater drainage — in a manner that reduces flood risk while also protecting natural values is a significant challenge. New approaches are being developed — and in some instances rediscovered — to provide for efficient runoff or detention of stormwater while simultaneously maintaining or creating valuable wildlife habitat and recreational or open space areas. Greater information sharing is necessary to speed the application of environmentally sensitive techniques for stormwater management.

Perhaps the greatest structural issue facing the Nation in the coming decades concerns the aging inventory of existing flood control structures. Many of the existing dams and reservoirs are near or past their design life. The structural integrity of these facilities is of concern, but perhaps even more important is the reduction in reservoir flood control capacity due to anticipated and/or unanticipated sedimentation and the fact that more stringent design standards apply now than when the structures were originally built.

State and federal agencies must now face important decisions related to loss of flood storage capacity and the high costs associated with structure maintenance. Local and private owners are also faced with high costs associated with maintenance and repair of dams and other structural measures. Even though federal and state dam safety programs have been greatly strengthened within the last 10 years, financial resources are not available to undertake required remedial actions. One approach being actively considered by the Soil Conservation Service, and used on a limited basis by the SCS and others, is to breach dams that are no longer required.

CHAPTER 13:

MODIFYING THE IMPACTS OF FLOODING

Floods are an act of God; flood damages result from acts of man.

House Document 465, 1966

Despite efforts to control flooding and to reduce susceptibility to flooding, floods do occur, with adverse consequences on individuals and communities. Therefore, a "third strategy for mitigating flood losses consists of actions designed to assist individuals and communities in their preparatory, survival, and recovery responses to floods. Tools[1] include information dissemination and education, arrangements for spreading the costs of the loss over time, and purposeful transfer of some of the individual's loss to the community" (Federal Emergency Management Agency, 1986).

INFORMATION AND EDUCATION[2]

Information and education activities for most aspects of floodplain management have expanded dramatically since the 1960s. This is illustrated by the vast increase in the number of: publications produced and distributed, including technical manuals and brochures and other public information materials; conferences, symposiums and workshops held; organizations formed that are directly or indirectly involved in floodplain management efforts through flood loss reduction and/or natural resources protection efforts; and print and broadcast media presentations. This increase in information has affected both flood loss reduction and natural resources management. Only a limited amount of the information produced, however, has served to integrate the flood loss reduction and natural

[1] In *A Unified National Program for Floodplain Management* (1986), disaster assistance is listed as a tool under the strategy to modify susceptibility to flooding. For purposes of the *Assessment Report*, disaster assistance is described in this chapter along with other tools to modify the impacts of flooding.

[2] *A Unified National Program for Floodplain Management* groups information and education with other tools under the strategy to modify the impacts of flooding. Information and education are actually components of every strategy and tool for floodplain management, and in the *Assessment Report* have been addressed directly or indirectly in the descriptions of most floodplain management tools. Additional descriptions of information and education topics not specific to other floodplain management tools are provided in this section of this chapter. Mapping of floodplains and related resources — a major information-related activity — is described in chapters 6 and 11.

resources protection aspects of floodplain management efforts. Flood loss reduction and natural resources protection efforts have generally been integrated to a greater extent in coastal areas than in riverine areas.

As one indication of the amount of floodplain management information produced, Table 13-1 shows the number of flood and other hazard-related publications listed by the Natural Hazards Research and Application Information Center (NHRAIC) at the University of Colorado, Boulder for the years 1975-1987.

FEDERAL ACTIVITIES

Federal agencies have directly developed or sponsored much of the original information that today provides the base of data on which floodplain management activities are built. The range of federal information and education involvement includes such diverse activities as publication of *A Unified National Program for Floodplain Management*, highly technical design and application manuals, research reports, computerized data bases, and public awareness materials. As just one example of the continuing flow of information, the National Science Foundation (NSF) recently released a package of information on natural hazards, including a summary report on natural hazards research recommendations, bibliographic data base software, and computer data files on recent major research reports (Butler, 1989). The total volume of materials produced and distributed, and the total number of individuals trained may be greater at the state level, but much of the basic information has originated with federal agencies.

Federal agencies have also been very active in providing training in various aspects of floodplain management. Each agency trains its own personnel in agency programs and activities. In addition, federal agencies have been very active in providing and supporting literally hundreds of conferences, seminars, and workshops on every aspect of floodplain management. The Corps of Engineers (Corps), Federal Emergency Management Agency (FEMA), National Weather Service (NWS), Tennessee Valley Authority (TVA), Soil Conservation Service (SCS), and U.S. Geological Survey (USGS) have been particularly active in lending their financial and technical support to a wide range of conferences, symposiums, workshops, and other educational activities that reach floodplain management professionals at all levels of government and in the private sector, and affected floodplain residents as well.

One of the major training programs is operated by FEMA at its Emergency Management Institute (EMI) in Emmitsburg, Maryland. Through this training facility, FEMA has provided training to hundreds of state and local government personnel across the country, as well as representatives of the private sector. Courses have included training in general floodplain management, postflood recovery, hazard mitigation teams, disaster assistance programs, operation of disaster application centers, preparation of Section 406 plans, hazard mitigation planning, and other activities. To reach a greater audience, several of the training courses initially conducted at the EMI have been modified for use by FEMA regional offices and by state agencies (Federal Emergency Management Agency, 1988).

Table 13-1. NHRAIC Annotated Bibliographies of Hazards Publications, 1975-1987.

	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87
CLIMATE AND DROUGHT	11	7	7	15	19	15	12	7	12	13	16	21
COASTAL ZONE MANAGEMENT AND PLANNING	4	12	9	17	19	12	12	9	12	5	15	16
EARTHQUAKES AND TSUNAMIS	59	20	48	34	54	47	65	52	49	40	59	68
FLOODS	60	28	54	45	60	37	31	36	39	25	32	32
HURRICANES, CYCLONES, TORNADOES AND SEVERE STORMS	11	9	20	22	13	18	11	13	16	12	19	16
LANDSLIDE AND OTHER MASS EARTH MOVEMENTS	3	0	4	7	4	7	9	5	6	10	12	7
MISCELLANEOUS HAZARDS										5[b]	25[b]	24[b]
AVALANCHES	3	0	0	0	0	0	0	0	0	0	0	0
COASTAL ZONE HAZARD AND EROSION	4	0	0	0	0	0	0	0	0	0	0	0
GENERAL	2	0	5	14	4	0	27	21	25	0	0	0
MULTI-HAZARDS												
BUILDING DESIGN AND CONSTRUCTION	0	8	8	1	4	6	3	0	0	0	0	0
GENERAL	41	10	36	40	36	9	53	45	57	42	54	71
HAZARDS PLANNING	0	4	10	6	13	15	2	7	11	10	7	0
HEALTH AND MEDICAL	0	4	9	10	9	15	8	8	15	10	21	17
LAND USE	6	9	8	7	10	2	1	52	0	0	0	
TECHNICAL HAZARDS	0	0	0	0	0	0	0	0	0	19	22	27
VOLCANOES	7	0	4	0	18	16	14	11	7	5	7	6
WATER RESOURCES AND WETLANDS MANAGEMENT	0	2	0	7	8	7	7	5	20	9	11	9
TOTAL	211	113	222	225	271	216	255	224	271	205	300	314

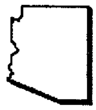
(b) Not divided into sub-categories.

Source: Morton, David R. A Selected Bibliography of Recent Hazards Publications, (Issues 1975-76 through 1986-87). Natural Hazards Research and Application Information Center. Boulder, Colorado: University of Colorado, 1988.

STATE AND LOCAL ACTIVITIES

Since about 1970, states have released literally thousands of documents relating to floodplain management. Many of these are based on documents published by federal agencies such as FEMA, the Corps, the SCS, the Environmental Protection Agency (EPA), and others. In this manner, information prepared by the federal agencies receives much wider distribution than it otherwise would, and the information can be tailored to the particular legal, administrative, and geographic situations of each state. In 1988, the Association of State Floodplain Managers (ASFPM), with funding support from federal agencies and private sources, initiated a Floodplain Management Resource Center located at the University of Colorado at Boulder. The Resource Center became operational during the first half of 1989 and includes a collection of floodplain management publications with a computerized indexing system to quickly locate appropriate references (Watson, 1988, 1990).

Table 13-2 displays three types of information and education activities related to flood loss reduction and provided by states as indicated by a 1988 survey. These activities are: 1) providing information in response to inquiries ("I"); 2) publishing manuals, handouts, or other publications ("P"); and 3) conducting training workshops or conferences ("T"). The activities may be directed toward local officials, insurance agents and lenders, and property owners, and may also be in response to insurance questions from the general public. Several specific examples of state information and education activities are provided below (Association of State Floodplain Managers, 1988).



Arizona maintains a community status report and a list of local administrators on a personal computer. The data file also includes areas currently being mapped, areas to be studied under FEMA's Limited Map Maintenance Program (LMMP), and other areas for which communities have requested detailed mapping information. Restudy areas are listed by priority and cost/benefits.

Almost every state is active in assisting and providing information to local officials on a variety of floodplain management topics, especially floodplain regulations typically addressed through the local code enforcement staff.

The second most common topic for information requests/assistance is flood insurance. Most states will answer questions on the National Flood Insurance Program (NFIP), and several have published manuals or hand-outs to help respond to requests for information. Examples include: "Flood Insurance Facts - A Consumer Guide to the National Flood Insurance Program in Missouri," "Flood Insurance Facts to Help You" published by the Kansas Insurance Department, and Louisiana's "Homeowner's Guide to the National Flood Insurance Program."

Insurance agents and lenders are also helped, as one state official noted, "because we have to answer the phone." Eight states conduct training sessions for agents and lenders.

Texas invites lenders, agents, realtors, and others to workshops on the NFIP, tailored to the host county's flood situation.

Table 13-2. State Activities in Floodplain Management Information and Education.

	LOCAL OFFICIALS	INSURANCE QUESTIONS	AGENTS & LENDERS	PROPERTY OWNERS
Alabama	I,T	I		I
Alaska	I,T,P	I	I,T	I
Arizona	I,P,T	I		I
Arkansas	I,T	I		
California	I,T,P	I,T,P	I,T	I,T,P
Colorado	I,T,P	I	I	I,T,P
Connecticut	I,T,P	I	I	I
Delaware	I			
District of Columbia	N/A	I		I
Florida	I,T	I	I	
Georgia	I,T	I	I,T	I
Hawaii	I	I	I	I
Idaho	I,T	I	I	
Illinois	I,T,P	I,P	I	I,T,P
Indiana	I,T,P	I,P	I,P	I,P
Iowa	I,T	I	I	I
Kansas	I,T	I,P		
Kentucky	I,T,P	I,P	I	
Louisiana	I,P	I,P		P
Maine	I,T	I	I	I
Maryland	I,T,P	I	I,P	I,P
Massachusetts	I,T	I		P
Michigan	I,T,P	I,T,P	I,P	I,P
Minnesota	I,T,P	I		P
Mississippi	I	I		
Missouri	I,T,P	P		I,T,P
Montana	I,T,P	I,P	I,T	I,P
Nebraska	I,T,P	I	I,T	P
Nevada	I	I	I	
New Hampshire	I,T	I		
New Jersey	I,T	I		I,T
New Mexico		I		
New York	I,T,P	I	I,T	I
North Carolina	I,T,P	I	I,T	I
North Dakota	I,T	I	I	
Ohio	I,T,P	I	I	I
Oklahoma	I,T	I,P	I	
Oregon	I,T			
Pennsylvania	I,T,P	I,P	I	I,P
Rhode Island	I,T,P	I	I	I
South Carolina	I,T			I,T,P
South Dakota	I,T	I	I	
Tennessee	I,T	I		I
Texas	I,T,P	I,P	I,T	I,P
Utah	I,T,P	I		I,P
Vermont	I,T	I		
Virginia	I	I		
Washington	I,T			
West Virginia				
Wisconsin	I,T,P	I		
Wyoming	I			

I = Provide information in response to inquiries
P = Publications or manuals
T = Training workshops or conferences

Source: Association of State Floodplain Managers. "State Floodplain Management Programs. Results of a Survey Conducted by the Association of State Floodplain Managers for L.R. Johnston Associates," 1988.

Property owners need information on the NFIP, floodproofing, flood emergency preparedness, and other methods to protect themselves from flood loss. A few states provide guidance on flood protection.

In Tennessee, a community planner will visit a site upon request, recommend actions, and direct the owner to more information or help.

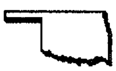
An interesting example of the use of specialized publications is from Maryland. The Maryland Department of Natural Resources created "Farley Floodhound," a cartoon character who appears in a coloring book and helps "flood pups" learn flood safety tips.

Most states that do advise property owners do so with publications such as floodproofing manuals. This approach helps the state reach a large audience and avoids the concern of many state officials that they may be liable for damages if a property owner takes their advice and is later flooded.

One very helpful information activity is to advise potential property purchasers or renters, as well as realtors, lenders and builders, about the flood hazard. Several states distribute brochures prepared by the TVA, others have prepared their own brochures. Examples include: "Suggestions for Prospective Buyers of Waterfront Property in Rural Wisconsin" and Minnesota's "Before You Buy or Build in the Floodplain: What You Should Know." Other states require more direct action.

Arizona is preparing a short course for real estate agents to be presented at local real estate schools.

In Wisconsin, if a property is shown as floodprone on NFIP maps, state law requires realtors to make that fact known to prospective property buyers.



Oklahoma's legislature passed a law in 1986 that requires: "If the premises to be rented has been flooded within the past five years and such fact is known to the landlord, the landlord shall include such information prominently and in writing as part of any written rental agreements."

PRIVATE SECTOR ACTIVITIES

Private sector activities with regard to information and education have also increased dramatically. This is particularly evident in the number of nonprofit and professional organizations formed in recent years to provide information and education on some aspect of floodplain management. Tables 7-2 and 7-3 in Chapter 7 list many of the national organizations concerned with floodplain management. Table 7-1 lists the major academic institutions with research or educational programs for the study of natural hazards and emergency management, including floodplain management. These organizations and institutions are active in conducting research, producing publications, holding conferences and workshops, and providing a network for professionals to exchange information.

EFFECTIVENESS OF INFORMATION AND EDUCATION ACTIVITIES

The effectiveness of information and education activities is difficult to assess. An individual assessment of the effectiveness of activities for each specific purpose would be necessary, and this type of assessment has not been undertaken. Most research on hazards-related information and education has focused on the effectiveness of warnings issued to the public. This research has shown that information regarding floods and other hazards is most accepted if disseminated by a recognized and credible authority (possibly a local mayor, for example), if the information provided is consistent, and if the information is repeated frequently and through various media. Research has further indicated that friends and relatives have a strong influence on an individual's acceptance of the information provided.

Concern is frequently expressed regarding the lack of basic understanding by local officials and property owners of the need for floodplain management. Many people simply do not have a good understanding of concepts of probability, cumulative impacts, off-site impacts, and functional values — all of which are important to understanding various aspects of floodplain management. As long as the majority of the public — those living in floodplains as well as those who do not — fail to understand the need for proper floodplain management, the effectiveness of information and education efforts for specific management activities will fall short of desired goals. Finding the best means of informing and educating people regarding floods, floodplains, and floodplain management will remain a challenge.

FLOOD INSURANCE

Insurance is a mechanism for spreading the cost of losses over time and over a relatively large number of similarly exposed risks. Until 1969, insurance against flood losses was generally unavailable. Under the National Flood Insurance Program initiated in 1968 and significantly expanded in 1973, the federal government makes flood insurance available for existing property in flood hazard areas. This insurance is available in return for local enactment and enforcement of floodplain management regulations designed to reduce future flood losses and regulate new development in the designated flood hazard areas (Federal Emergency Management Agency, 1986).

NATIONAL FLOOD INSURANCE PROGRAM

The National Flood Insurance Program was authorized by Congress in the National Flood Insurance Act (NFIA) of 1968. The program is administered by the Federal Insurance Administration (FIA), originally as part of the Department of Housing and Urban Development (HUD), and since 1979 as part of the Federal Emergency Management Agency. The NFIP does far more than simply provide flood insurance. It encompasses a broad program of floodplain management activities, including performance of flood risk studies and preparation of maps of flood hazard areas, as well as provision of technical assistance for many purposes (e.g., floodproofing) to states and communities. In addition, the NFIP establishes requirements for participating communities to adopt minimum floodplain regulations. NFIP activities in addition to flood insurance activities are described in other chapters of the *Assessment Report*. The total program of the NFIP has probably been the most dominant influence on floodplain management over the past 15 years.

Eligibility for Flood Insurance

Flood insurance is made available for both structures and the contents of structures within each community that participates in the NFIP. When the NFIP was first established, participation in the program was restricted to communities for which a flood risk assessment study (called a Flood Insurance Study or FIS) had been completed. Because FISs were detailed and time-consuming, few communities were able to join the program immediately.

The Housing and Urban Development Act of 1969 expanded participation in the NFIP by authorizing an "Emergency Program" providing insurance coverage at nonactuarial, federally subsidized rates in limited amounts during the period prior to completion of a community's FIS. To participate in the Emergency Program, communities were required to adopt and enforce only minimal floodplain management standards.

To increase community participation in the NFIP and to achieve other objectives, the Flood Disaster Protection Act of 1973 amended the NFIP in several ways. First, it required the FIA to formally notify all floodprone communities of their flood hazards as a means of encouraging program participation; second, it substantially increased the limits of insurance coverage; and third, it introduced provisions for withholding certain federal benefits from floodprone communities that chose not to participate in the NFIP and from owners of floodprone structures unwilling to purchase flood insurance. Following these program amendments, participation in the NFIP grew rapidly. As of November 30, 1990, a total of 18,023 communities were participating in the Program: 280 in the Emergency Program and 17,743 in the Regular Program[3] (Matticks, 1990).

Flood insurance is not restricted to structures located within the designated floodplain subject to a one percent annual chance flood, but is available for any eligible structure located in a community participating in the NFIP.

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3 See the section on Floodplain Regulations in Chapter 11 for a description of the differences between the Emergency and Regular phases of the NFIP.

Mandatory Purchase Requirements.

In general, purchase of flood insurance is voluntary. However, any federally regulated or insured financial institution (primarily banks and savings and loan institutions) that provides financial assistance for the purchase of property located in the one percent annual chance floodplain of a community participating in the NFIP must require that flood insurance be purchased and maintained for the property. Lenders must determine if the property is located in a floodplain, notify the borrower, and require insurance. Since there is no penalty for a lender that fails to comply, however, there is no real economic incentive for most lenders to be diligent in following this requirement. In fact, there is considerable evidence to indicate that this requirement is generally not being met. NFIP statistics show that only a small percentage of structures in special flood hazard areas have insurance, and a recent postdisaster study by FEMA showed a high rate of failure by lenders to apply the requirements.

There are several adverse consequences of this failure on the part of many lending institutions:

- Far fewer flood insurance policies are sold than would be otherwise, reducing the total pool of policy holders, and negatively affecting the flood insurance program.
- Individuals without flood insurance and who are subsequently flooded may receive disaster assistance that might otherwise be unnecessary, thereby creating an unnecessary drain on federal, state, local, and private funds.
- Individuals may be moving into the floodplain without adequate knowledge of the hazard or of the added costs they may face due to flood insurance and other possible costs. The prospective owner may therefore not have an opportunity to decide against acquiring property based on knowledge of vulnerability to flooding.
- Lenders face possible lawsuits if the property owner subsequently sustains flood damages.

To address these concerns, the following actions can be considered:

- Modify existing federal legislation to impose financial penalties on lenders.
- Provide greater training and education for lenders regarding their responsibilities and liability.
- Provide mechanisms that will make it easier for lenders to make the floodplain determination.
- Impose requirements on real estate brokers to disclose if a property is located in a special flood hazard area and that flood insurance may be required.
- Require that the location of the property within a special flood hazard area be filed with the deed to the property.
- Encourage greater involvement by the private sector. Several firms are already operating throughout the country to provide map determinations to banks, individuals, and local governments.
- Provide some legal mechanism to assure state and local government officials that they will not face liability if they provide assistance in making map determinations and someone is later flooded.

Rates and Limits of Coverage.

The federal government established the NFIP in 1968 because flood insurance was generally not available to floodplain residents. Private insurance companies had found it unprofitable to provide flood insurance, since only those individuals who were most susceptible to flooding were willing to purchase the insurance. To make flood insurance available at a reasonable cost, the federal government, through the NFIP, provides insurance at subsidized rates for structures existing before detailed information on the flood hazard was available. The federal government pays for all claims up to the level of coverage, minus the deductible selected by the policyholder when purchasing the flood insurance policy. Insurance rates are not subsidized for new structures built after Flood Insurance Rate Maps (FIRMs) for the community are prepared.[4] One goal of the NFIP is to gradually reduce the level of subsidy until the entire program can operate on an actuarial basis.

Insurance premiums are based on the location of a structure within the floodplain, and are determined primarily by the height of the structure's first floor relative to the height of floodwater during a base (one percent annual chance) flood. Higher rates apply to structures subject to velocity waters (structures within V-zones). New and substantially improved structures in the floodplain are subject to higher rates than structures already in the floodplain at the time a community joined the NFIP. Since 1974, flood insurance rates have increased several times to reduce the amount of the federal subsidy and bring the cost of flood insurance closer to true actuarial rates. Table 13-3 shows NFIP rate revisions since 1974. In early 1988, the Administrator of the FIA announced that premium rates would remain stable for at least two years, and that the FIA "has been successful in achieving the goal of making the NFIP self-supporting for the historical average loss year." The average annual premium increased from about $75/year in 1981 to about $265/year in 1988. This increase is partially due to an increase in the average amount of insurance coverage purchased, which is currently over $80,000; up from about $55,000 five years ago (Watson, 1989).

Insurance coverage is provided for both structures and contents. The amount of insurance available depends on whether a community is participating in the Emergency or Regular Phase of the NFIP. Table 13-4 shows the maximum amounts of flood insurance available for different types of structures for both the Emergency and Regular phases of the NFIP. Some changes in coverage have been made since the program was initiated, particularly to increase the deductible and limit coverage available for the contents of basements.

Number of Policies and Claims

Although flood insurance coverage is now available through local insurance agents or brokers in over 18,000 communities that participate in the NFIP, only one-quarter to one-third of the approximately nine million U.S. buildings exposed to flooding risks are insured.

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4 Structures built before December 31, 1974, however, may also be insured using subsidized rates, even if the FIRM for the community was issued prior to that date.

Table 13-3. National Flood Insurance Program Rate Revisions Since January 1, 1974.

EFFECTIVE DATE	PERCENT CHANGE	INDEX
1973		1.00
January 1, 1974	-44	0.56
July 1, 1974	-4	0.54
January 1, 1981	34	0.72
October 1, 1981	28	0.92
June 1, 1982	20	1.10
October 1, 1983	11	1.22
March 1, 1986	6	1.29
October 1, 1986	6	1.37
June 1, 1987	5	1.44
September 1, 1988	10	1.63

Source: U.S. General Accounting Office. Flood Insurance: Statistics on the National Flood Insurance Program. Fact Sheet for Congressional Requesters. GAO/RCED-88-155FS, 1988.

At the end of calendar year 1987, there were a total of 2,056,680 policies in force with $113,843,556,592 of insurance coverage (Flood Insurance Producers National Committee, 1988). Table 13-5 shows the number of policies and insurance coverage, by state, in 1987. At the end of 1990 there were 2.39 million policies in force with $201 billion in coverage. A state-by-state breakdown of policies and coverage is not available at this time (Federal Emergency Management Agency, 1991).

From 1978 through 1989, a total of over 384,000 claims were paid with a value in excess of $3.1 billion. Table 13-6 lists, by state, the number and amount of claims paid for the period of 1978-1987.

As shown in Table 13-7, the difference between net receipts from policy premiums and claims payments varies substantially from year to year. For the period 1978 to 1989, the net operating deficit or surplus ranged from a deficit of $261 per policy in 1979, to a surplus of $98 per policy in 1987. A surplus of premiums over claims payments was realized in fiscal years 1986, 1987 and 1988. As of October 1, 1988, the flood insurance fund was operating with a net surplus of $450 million. According to the FIA, the surplus generated in 1986-1988 resulted from a combination of rate increases and relatively low flood losses, and the accumulated surplus provides a reserve for years with catastrophic losses (Federal Insurance Administration, 1988).

Table 13-4. Maximum Amounts of Flood Insurance Available.

PROGRAM AND BUILDING TYPE	AMOUNT AVAILABLE BUILDING(a)	CONTENTS(a,b)
Emergency Program:		
Single-family residence(c)	$35,000	$10,000
Other residential(c,d)	100,000	10,000
Nonresidential(e)	100,000	100,000
Regular Program:		
Single-family residence	185,000	60,000
2-4 family residence	250,000	60,000
Other residential(f)	250,000	60,000
Small business(g)	250,000	300,000
Other nonresidential(h)	200,000	200,000

(a) The maximum flood insurance available is set forth by the National Flood Insurance Act of 1968 (P.L. 90-448), as amended by the Disaster Assistance Act of 1973 (P.L. 93-234).

(b) Limit per unit.

(c) Higher maximum amounts are available in Alaska, Guam, Hawaii, and the U.S. Virgin Islands.

(d) A residential building, excluding hotels and motels with normal room rentals for less than 6 months, that contains 2 or more dwelling units.

(e) A nonresidential building includes, but is not limited to: small businesses, churches, schools, nursing homes, farm buildings, government buildings, mercantile structures, industrial plants, and warehouses.

(f) A residential building, excluding hotels and motels with normal room rentals for less than 6 months, containing more than 4 dwelling units.

(g) A business, together with its affiliates, that does not have a net worth in excess of $6 million, and does not have an average net income after federal income taxes (excluding any carry-over losses) for the preceding two years in excess of $2 million.

(h) A nonresidential building other than a small business.

Source: U.S. General Accounting Office. Flood Insurance: Statistics on the National Flood Insurance Program. Fact Sheet for Congressional Requesters. GAO/RCED-88-155FS, 1988.

Table 13-5. Number of Flood Insurance Policies and Amount of Insurance by State, 1987.

CALENDAR YEAR 1987
DIRECT AND WYO(b) COMBINED

STATE(a)	NUMBER OF POLICIES	AMOUNT OF INSURANCE	WRITTEN PREMIUM
Alabama	17,176	$ 738,556,687	$ 4,556,898
Alaska	2,172	62,044,958	474,452
Arizona	20,857	675,930,819	4,937,291
Arkansas	6,682	113,153,031	1,482,606
California	110,700	3,449,831,921	30,311,748
Colorado	8,232	186,899,201	2,228,008
Connecticut	17,573	574,394,040	6,321,552
Delaware	6,710	491,580,924	2,129,550
Dist. of Columbia	42	720,479	28,775
Florida	714,327	53,059,644,551	188,650,415
Georgia	19,930	1,062,021,325	5,066,186
Guam	26	11,303	7,773
Hawaii	9,254	416,975,358	3,576,794
Idaho	1,684	33,613,292	393,071
Illinois	23,484	399,938,881	5,652,207
Indiana	12,706	197,955,390	2,825,282
Iowa	4,450	67,707,633	1,044,600
Kansas	6,882	72,028,244	1,505,797
Kentucky	13,961	401,646,758	3,434,637
Louisiana	240,783	13,829,024,764	55,330,229
Maine	5,290	175,227,036	1,553,924
Maryland	22,929	1,273,345,242	6,138,474
Massachusetts	25,250	347,496,629	8,395,941
Michigan	17,354	432,677,825	4,152,490
Minnesota	4,899	91,115,034	1,260,843
Mississippi	32,868	1,521,793,482	7,254,782
Missouri	14,552	209,331,660	3,631,236
Montana	1,428	12,413,560	317,296
Nebraska	7,488	135,585,148	1,528,809
Nevada	5,385	100,341,432	1,321,177
New Hampshire	2,956	65,041,379	898,482
New Jersey	113,770	5,618,093,264	34,247,492
New Mexico	4,638	85,896,683	1,015,034
New York	62,356	1,738,759,341	17,908,263
North Carolina	38,066	1,621,186,678	9,783,509
North Dakota	5,130	68,433,114	1,153,921
Ohio	14,358	223,716,503	3,459,521
Oklahoma	11,484	219,167,324	2,782,920
Oregon	5,505	85,172,922	1,372,870
Pennsylvania	55,405	1,431,833,803	14,715,636
Puerto Rico	8,007	14,227,639	1,545,629
Rhode Island	7,629	185,259,656	2,753,574
South Carolina	46,361	4,151,536,594	12,660,585
South Dakota	817	10,189,974	185,309
Tennessee	6,687	177,822,915	1,640,044
Texas	225,275	15,327,249,275	59,902,831
Utah	1,552	25,204,318	385,504
Vermont	2,013	46,918,293	529,374
Virgin Islands	1,764	26,702,574	513,593
Virginia	36,368	2,068,974,649	8,910,838
Washington	10,442	142,729,050	2,513,498
West Virginia	13,330	274,550,039	3,430,325
Wisconsin	6,297	75,310,508	1,526,399
Wyoming	1,396	26,573,514	343,550
TOTAL	2,056,680	$113,843,556,592	$539,691,544

(a) "State," as defined by FEMA program regulations, means any state, the District of Columbia, the territories and possessions of the United States, the Commonwealth of Puerto Rico, and the Trust Territory of the Pacific Islands.

(b) Write Your Own Program. See pages 13-25 and 13-26 for a description of this program.

Source: Flood Insurance Producers National Committee. FIPNC. Vol. II, Bulletin #3, November 1988.

Table 13-6. Number and Amount of Flood Claims Paid by State, 1978-1987.

TEN YEARS 1978 - 1987
NUMBER AND AMOUNT OF
FLOOD CLAIMS PAID

STATE	NUMBER OF CLAIMS PAID	AMOUNT OF CLAIMS PAID
Alabama	7,258	$ 87,805,791
Alaska	54	322,839
Arizona	1,395	14,064,010
Arkansas	1,457	10,800,307
California	10,703	108,846,266
Colorado	426	3,223,467
Connecticut	5,709	34,906,126
Delaware	423	1,929,167
Dist. of Columbia	7	101,518
Florida	25,652	165,125,349
Georgia	1,318	8,455,396
Guam	2	17,492
Hawaii	715	10,354,101
Idaho	117	499,193
Illinois	15,145	81,307,867
Indiana	2,901	13,289,339
Iowa	860	3,101,421
Kansas	1,688	12,957,557
Kentucky	5,075	48,913,951
Louisiana	63,341	502,019,965
Maine	1,643	15,921,597
Maryland	2,355	21,859,402
Massachusetts	7,120	40,890,955
Michigan	4,945	23,999,710
Minnesota	2,419	16,518,655
Mississippi	13,176	108,496,982
Missouri	16,486	113,043,717
Montana	575	1,943,610
Nebraska	1,501	9,460,795
Nevada	208	1,891,589
New Hampshire	708	3,729,914
New Jersey	18,594	117,979,379
New Mexico	123	490,587
New York	29,239	105,271,504
North Carolina	2,925	15,495,792]
North Dakota	2,275	9,786,873
Ohio	5,850	29,549,982
Oklahoma	4,165	60,986,298
Oregon	466	2,404,346
Pennsylvania	12,784	61,971,275
Puerto Rico	8,089	32,200,608
Rhode Island	859	7,828,172
South Carolina	2,730	10,324,333
South Dakota	347	1,403,419
Tennessee	1,421	8,482,208
Texas	55,862	575,588,046
Utah	436	4,439,661
Vermont	330	1,403,419
Virgin Islands	529	8,482,208
Virginia	4,360	59,077,329
Washington	1,307	13,196,518
West Virginia	6,975	67,738,531
Wisconsin	949	3,295,144
Wyoming	152	1,038,852
TOTAL	356,149	$2,657,819,907

Source: Flood Insurance Producers National Committee. FIPNC. Vol. II, Bulletin #3, November 1988.

Table 13-7. National Flood Insurance Program: Underwriting Experience by Calendar Year/Accident Year, 1978-1987.

	1978	1979	1980	1981	1982
1) AVERAGE AMT. OF INS. PER POLICY	$33,150	$37,650	$45,101	$50,883	$55,168
2) EARNED PREMIUM	$81,813,509	$125,483,655	$149,179,251	$180,984,641	$247,700,475
3) LOSSES INCURRED	$147,672,767	$483,237,012	$230,341,570	$127,100,112	$198,243,095
4) LOSS ADJUSTER EXPENSE	$7,914,631	$22,501,561	$13,563,102	$7,775,372	$11,140,752
5) LOSS AND LOSS ADJUSTER RATIO	1.902	4.030	1.635	0.745	0.845
6A) INSURANCE AGENT COMMISSION - DIRECT	$13,515,233	$20,729,357	$25,435,596	$29,280,077	$42,209,515
6B) AGENT COMMISSION ALLOWANCE - WYO	NA	NA	NA	NA	NA
7A) GENERAL EXPENSE - DIRECT (a)	$13,924,450	$16,536,232	25,599,361	$31,117,236	$28,290,194
7B) OPERATING ALLOWANCE - WYO	NA	NA	NA	NA	NA
8) PROFIT TO SERVICING FACILITY	$1,017,623	$1,390,706	$2,596,091	$1,767,883	$2,852,968
9) EARNED EXPOSURE	$1,059,761	$1,624,268	1,953,211	1,967,255	1,892,266
10) AVERAGE PREMIUM	$77.20	$77.26	$76.38	$92.00	$130.90
11) AVERAGE OPERATING COST OTHER THAN AGENT COMMISSION AND LOSS ADJUSTER EXPENSE (b)	$14.10	$11.04	$16.48	$16.72	$16.46
12) AVERAGE INSURANCE AGENTS COMMISSION (c)	$12.75	$12.76	$13.02	$14.88	$22.31
13) AVERAGE LOSS AND LOSS ADJUSTER COST PER POLICY	$146.81	$311.36	$124.87	$68.56	$110.65
14) OPERATING PROFIT/(DEFICIT) PER POLICY (d)	($96.47)	($257.91)	($78.00)	($8.16)	($18.52)

(Continued)

(a) Includes $2,391,144 for development, printing and distribution of the new flood insurance manual and the business system to support its implementation, for 1980.

(b) Operation cost is funded on an ongoing basis (starting in 1981) by the collection of an expense constant from each policyholder.

(c) A savings of $571,260 in commission was negotiated with the insurance agents of Puerto Rico by the FIA in connection with 57,126 policyholders who were required to purchase insurance as a condition of federal disaster relief, for 1990.

(d) Prior to the 1990 analysis, a positive number on this line represented an operating deficit per policy.

Sources: National Flood Insurance Association. 1970-77 Financial and Statistical Reports; EDS Federal Corporation (Servicing Facility), as presented by CSC's EAIS. 1978-79 Financial and Statistical Reports; CSC, Servicing Facility through its EAIS, 1980-89 Financial and Statistical Reports.

Table 13-7. (Cont.) National Flood Insurance Program: Underwriting Experience by Calendar Year/Accident Year, 1978-1987.

	1983	1984	1985	1986	1987
1) AVERAGE AMT. OF INS. PER POLICY	$58,105	$61,862	$66,888	$71,110	$76,700
2) EARNED PREMIUM	$313,023,597	$334,865,116	$364,767,808	$403,326,133	$452,675,995
3) LOSSES INCURRED (f)	$439,457,608	$254,599,652	$368,977,214	$126,936,225	$104,659,319
4) LOSS ADJUSTER EXPENSE (f)	$21,361,786	$11,206,399	$13,721,600	$4,814,996	$4,193,493
5) LOSS AND LOSS ADJUSTER RATIO	1.472	0.794	1.049	0.327	0.240
6A) INSURANCE AGENT COMMISSION - DIRECT	$46,953,540	$47,797,423	$43,866,513	$34,012,166	$26,752,857
6B) AGENT COMMISSION ALLOWANCE - WYO	NA	$2,432,344	$10,848,658	$26,486,753	$41,148,542
7A) GENERAL EXPENSE - DIRECT (e)	$31,131,245	$36,451,369	$34,025,399	$35,944,266	$30,261,948
7B) OPERATING ALLOWANCE - WYO	NA	$2,452,614	$12,421,713	$31,033,647	$45,949,205
8) PROFIT TO SERVICING FACILITY	$2,584,452	$2,618,700	$2,376,027	$2,487,001	$2,507,731
9) EARNED EXPOSURE	$1,917,613	$1,917,003	1,920,394	2,034,676	2,072,202
10) AVERAGE PREMIUM	$163.24	$174.68	$189.94	$198.23	$218.45
11) AVERAGE OPERATING COST OTHER THAN AGENT COMMISSION AND LOSS ADJUSTER EXPENSE (b)	$17.58	$21.66	$25.42	$34.14	$37.99
12) AVERAGE INSURANCE AGENTS COMMISSION	$24.49	$26.20	$28.49	$29.73	$32.77
13) AVERAGE LOSS AND LOSS ADJUSTER COST PER POLICY	$240.31	$138.66	$199.28	$64.75	$52.53
14) OPERATING PROFIT/(DEFICIT) PER POLICY (g)	($119.14)	($11.84)	($63.25)	$69.60	$95.17

(e) Includes contractor transition costs, for 1983.

(f) Beginning with 1985, includes an allowance for open claims.

(g) Prior to the 1990 analysis, a positive number on this line represented an operating deficit per policy.

Sources: National Flood Insurance Association. 1970-77 Financial and Statistical Reports; EDS Federal Corporation (Servicing Facility), as presented by CSC's EAIS. 1978-79 Financial and Statistical Reports; CSC, Servicing Facility through its EAIS, 1980-89 Financial and Statistical Reports.

Table 13-8 provides information on loss and expense experience in different risk zones for the period 1978-1987. Analysis of this information by the FIA shows that:

- Post-FIRM construction in the coastal high hazard area zones generated an operating surplus of $185 per policy. These policies for new construction are not intended to be subsidized and have not been subsidized. Because of relatively low flood losses in the last few years, even the pre-FIRM construction eligible for a subsidy has generated an operating surplus per policy of $12.

- Post-FIRM construction in areas where new construction is subject to NFIP floodplain management regulations experienced significantly lower loss frequencies and consequently significantly lower loss costs per policy. This indicates that NFIP flood loss reduction standards are effective in reducing flood losses to new construction.

- In all zones where post-FIRM construction has been subject to NFIP floodplain management standards, there has been an operating surplus for flood insurance policies. This reflects the design of the NFIP to not provide subsidies for new construction in the floodplain. With the exception of zones B, C and X, program deficits were only experienced for pre-FIRM construction eligible for a subsidy. Rating and coverage changes in the last few years have been aimed at correcting the B, C and X problem, and the NFIP expects these policies to be self-supporting in the future (Federal Insurance Administration, 1988).

Table 13-9 provides information on average annual premiums based on a comparison of the 1978-1987 loss experience with the projected written premium based on 1989 cost levels. The FIA notes that:

- Comparing the 1978-1987 loss experience with the average annual premium based on rates effective September 1, 1988, shows that the combined actuarial and subsidized rates results in a program expected to have only a 1.9 percent shortfall for the historical average loss year. The NFIP has essentially met its goal of being self-supporting at a level equivalent to the historical average.

- The actuarially rated policies, which comprise about 50 percent of the NFIP book of business, are to be paying premiums ranging from 103 percent to 185 percent of the premium indicated by the historical average. This reflects that these policies are being charged to cover catastrophic loss potential — a magnitude of loss not really reflected in the 1978-1987 time period. The NFIP rate structure is geared to provide a subsidy only for those pre-FIRM policies eligible to be subsidized (Federal Insurance Administration, 1988).

Table 13-8. National Flood Insurance Program: Loss and Expense Experience, 1978-1987.

	ZONES VE,V1-V30		UNNUMBERED ZONE A		ZONES AE,A1-A30				
	POST-FIRM	PRE-FIRM	POST-FIRM	PRE-FIRM	POST-FIRM	PRE-FIRM	ZONES B,C,X	EMERGENCY PROGRAM	PROGRAM TOTALS
1. Earned Exposure (earned policy terms)	82,705	468,227	264,238	1,095,942	1,069,168	5,218,977	5,369,538	3,246,779	18,535,187
2. Average Earned Premium	$352.26	$232.67	$201.70	$172.12	$132.39	$160.91	$119.25	$107.36	$142.67
3. Number of Paid Losses	993	8,893	1,183	21,307	5,356	106,136	64,437	102,449	337,965
4. Average Loss Payment	$7,191.17	$8,187.59	$8,420.79	$8,198.56	$9,885.42	$6,958.47	$7,614.82	$5,516.04	$7,164.43
5. Loss Ratio	0.25	0.67	0.19	0.93	0.37	0.88	0.77	1.62	0.92
6. Loss Frequency Per 100 Policies	1.2	1.9	0.4	1.9	0.5	2.0	1.2	3.2	1.8
7. Average Loss Cost Per Policy	$86.34	$155.51	$37.70	$159.39	$49.37	$141.51	$91.38	$174.05	$130.63
8. Other Expenses (average per policy)									
a) Agent Commission/ Allowance	$54.64	$36.09	$31.28	$26.70	$20.53	$24.96	$18.50	$16.65	$22.13
b) Loss Adjuster	$4.44	$6.47	$1.80	$6.71	$2.13	$$6.72	$4.22	$10.06	$6.24
c) Serving Facility/ WYO Operating Allowance	$21.63	$21.63	$21.63	$21.63	$21.63	$21.63	$21.63	$21.63	$21.63
9. Operating Surplus/(Deficit) Per Policy on Paid Basis*	$185.22	$12.97	$109.29	($42.31)	$38.73	($33.91)	($16.48)	($115.03)	($37.97)

* The operating surplus is the policyholder contribution in periods of relatively better loss experience towards reserves used to fund high loss years.

Source: Federal Insurance Administration. "Supplementary Data on the NFIP." Unpublished data from FIA/FEMA, 1988.

Table 13-9. National Flood Insurance Program: Annual Premium Loss Experience (1979-1987) vs. Projected Written Premium on 1989 Cost Level.

	AVERAGE ANNUAL PREMIUM BASED ON '78-'79 LOSS EXPERIENCE WITH LOSSES & EXPENSES ON 1989 LEVEL(a)	PROJECTED AVERAGE ANNUAL WRITTEN PREMIUM USING 9/1/88 RATES WITH PROJECTED INSURANCE AMOUNTS	PERCENTAGE OF ON LEVEL PREMIUM BASED ON '78-'87 EXPERIENCE(b)
A. Regular Program - Actuarial Rates			
Zones AE,A,AD,AH,AHB,AOB	126.96	105.64	146.2%
Zones VE,V	273.90	506.02	104.7%
Zones B,C,X,D	203.97	210.88	103.3%
Sub-Total Actuarial	174.50	203.10	116.4%
B. Regular Program - Subsidized Rates	347.89	312.83	89.9%
C. Emergency Program	368.95	231.31	62.7%
Sub-Total Subsidized	368.89	309.01	88.6%
D. NFIP Total	260.13	255.10	98.1%

(a) Includes $45.00 Expense Constant.
(b) Based on '78-'79 experience. Does not include consideration for development of catastrophic loss reserve. Simulation modeling for the NFIP indicates that, because the '78-'87 period does not include the large scale catastrophic year, the losses experienced in this time period will prove to be lower than the long-term average including catastrophic years.

Source: Federal Insurance Administration. "Supplementary Data on the NFIP." Unpublished data from FIA/FEMA, 1988.

Subsidized vs. Actuarial Rates

Initially, the NFIP provided heavily subsidized rates for practically all insurance premiums. The program has been gradually increasing premiums for new policies so that the premiums will reflect actuarial rates. One of FEMA's major goals is to make the NFIP self-supporting. FEMA currently interprets this goal as providing overall premium income sufficient to meet the loss and expense requirements of the historical average loss year (excluding potential catastrophic years), rather than relying on the authorized borrowing authority from the Federal Treasury. FEMA now estimates that this goal has essentially been met. The combined loss and expense ratio for 1978-1987 was 128%, that same ratio was only 55% in 1987. Such an extremely low loss year allows for the accumulation of reserves for future heavier loss years (Mrazik, undated).

Not everyone is convinced that charging actuarial rates produce the best floodplain management results. Concern has been expressed that flood insurance premium costs have increased to a level so high that many persons do not purchase flood insurance unless required to do so by a mortgage lender or unless they have experienced flooding. Many of those who do purchase insurance subsequently allow it to expire (DeGroot, 1989). The net result appears to be that only those individuals exposed to the greatest risk actually purchase and maintain flood insurance. To maintain actuarial rates for this group, insurance rates will have to be forced even higher (Burby, et al., 1988).

Repetitive Losses

Many of the claims paid out each year are for structures that have been previously damaged. FEMA defines a repetitive loss structure as one for which two or more losses of more than $1,000 (building and contents combined) have been paid during the most recent 10-year period. A repetitive loss is defined as a loss of more than $1,000 to a repetitive loss structure.

Repetitive losses have been one of the major concerns of the NFIP, particularly since many of the losses occur outside the designated base floodplain (the one percent annual chance floodplain). A recent analysis by the FIA (Federal Insurance Administration, 1990) indicates that during the 10-year period January 1980 through December 1989, there were 75,299 repetitive losses to 30,516 repetitive loss structures. Tables 13-10 through 13-15 provide information on repetitive claims and losses during this 10-year period.

Although most repetitive loss structures had two losses during the 10-year period, a few had three, four, or more losses. A high percentage of the dollars paid for repetitive losses are for contents coverage, indicating that removal of contents from vulnerable areas of the structure either permanently or immediately prior to a flood may prove to be a cost-effective mitigation technique.

Repetitive losses during the 1980s represent 27.5 percent of the total losses and 32.5 percent of the total dollar amount paid on all losses. The average claim for a repetitive loss structure is somewhat higher than for the NFIP as a whole, due at least in part to the exclusion of losses under $1,000 from the definition of repetitive loss. In addition, most losses resulting from Hurricane Hugo are not included in this data, and these losses will increase the average loss for the program as a whole.

The distribution of repetitive loss structures among zones is similar to the distribution for all losses. One notable difference is that 3.7 percent of all losses for the same period are for structures in Zones V, V1-30, and VE. This is substantially higher than the 2.9 percent of repetitive loss structures located in these same zones. Based on this information, it appears that repetitive losses caused by coastal flooding are of less concern than repetitive losses resulting from riverine and stormwater flooding.

The distribution of repetitive building damage claims indicates that for most repetitive losses, building damage is a relatively low percentage of building value (53.2 percent of repetitive losses are 10 percent or less of building value). The range of cost-effective floodproofing techniques for such structures is likely to be limited. In most cases, damages in excess of 50 percent meet the definition of substantial damage and are subject to NFIP elevation requirements and actuarial rates. The distribution of repetitive losses by the dollar amount of combined building and contents damage, however, shows that most repetitive losses are for relatively small dollar amounts.

Table 13-10. Basic Data for Repetitive Losses and Total NFIP Losses for the 10-Year Period 1980 through 1989.

Number of Repetitive Losses:	75,299
Total Amount Paid on these Lossses:	
Building	$434 million
Contents	$313 million
Total Building and Contents	$747 million
Average Amount Paid per Loss (Building and Contents):	$9,922
Number of Repetitive Loss Structures:	30,516
Average Number of Losses per Structure:	2.6
Number of Losses:	273,982
Total Amount Paid on these Losses:	
Building	$1.33 billion
Contents	$938 million
Total Building and Contents	$2.27 billion
Average Amount Paid per Loss:	$8,289

Source: Federal Insurance Administration, Office of Loss Reduction. "Summary and Assessment of National Flood Insurance Program (NFIP) Repetitive Loss Data." June 1990.

Table 13-11. Distribution of Pre-FIRM Repetitive Loss Structures by Zone.

ZONES(a)	NUMBER OF REPETITIVE LOSS STRUCTURES	PERCENT OF REPETITIVE LOSS STRUCTURES
A, AO, AH, A1-30, AE	17,530	59.7%
V, V1-30, VE	842	2.9%
B, C, X, D	6,194	21.1%
Unknown(b)	4,793	16.3%
	29,359	100.0%

(a) See Appendix C for definitions of A and V zones; see also Table 11-1.
(b) These policies are believed to be Emergency Program (Pre-FIRM) policies for which no zone was identified.

Source: Federal Insurance Administration, Office of Loss Reduction. "Summary and Assessment of National Flood Insurance Program (NFIP) Repetitive Loss Data." June 1990.

Table 13-12. Distribution of Repetitive Building Coverage Claims by Building Damage as a Percentage of Building Value.

PERCENT RANGE	NUMBER OF CLAIMS	PERCENTAGE OF CLAIMS
0-5%	27,392	34.8%
5-10%	14,508	18.4%
10-15%	8,773	11.1%
15-20%	6,343	8.0%
20-25%	5,012	6.4%
25-30%	3,870	4.9%
30-35%	2,888	3.7%
35-40%	2,152	2.7%
40-45%	1,571	2.0%
45-50%	1,221	1.5%
More than 50%(a)	5,068	6.4%
	78,798	99.9%

(a) These structures are substantially damaged and are subject to NFIP elevation requirements and actuarial rates.

Source: Federal Insurance Administration, Office of Loss Reduction. "Summary and Assessment of National Flood Insurance Program (NFIP) Repetitive Loss Data." June 1990.

Table 13-13. Distribution of Repetitive Losses by the Dollar Amount of Total Damages (Building and Contents Combined).

	NUMBER OF LOSSES	PERCENTAGE OF LOSSES
Less than $5,000	31,558	40.0%
$5,000 — $10,000	18,870	24.0%
$10,000 — $25,000	18,933	24.0%
$25,000 — $50,000	6,432	8.2%
More than $50,000	3,017	3.8%
	78,810	100.0%

Source: Federal Insurance Administration, Office of Loss Reduction. "Summary and Assessment of National Flood Insurance Program (NFIP) Repetitive Loss Data." June 1990.

Table 13-14. Distribution of Repetitive Losses by States (Top Ten States).

STATE	NUMBER OF REPETITIVE LOSSES	PERCENT OF REPETITIVE LOSSES	PERCENT OF ALL LOSSES
Louisiana	21,356	28.4%	20.8%
Texas	12,160	16.1%	16.3%
Missouri	5,636	7.4%	4.4%
New Jersey	4,620	6.1%	5.6%
New York	3,810	5.1%	6.5%
Illinois	3,754	5.0%	4.0%
Mississippi	3,418	4.5%	3.8%
Florida	3,383	4.5%	6.5%
California	2,358	3.1%	3.4%
Puerto Rico	2,348	3.1%	2.4%
	62,843	83.1%	73.7%

Source: Federal Insurance Administration, Office of Loss Reduction. "Summary and Assessment of National Flood Insurance Program (NFIP) Repetitive Loss Data." June 1990.

Table 13-15. Top 20 Repetitive Loss Communities by Number of Losses.

RANK	COMMUNITY	STATE	NUMBER OF LOSSES
1	Jefferson Parish	LA	7,871
2	Orleans Parish	LA	5,153
3	Houston, City of	TX	2,596
4	Harris County	TX	2,379
5	Puerto Rico, Commonwealth	PR	2,348
6	St. Charles County	MO	2,044
7	New York, City of	NY	1,256
8	St. Bernard Parish	LA	987
9	Wayne, Township of	NJ	742
10	Gretna, City of	LA	674
11	Kenner, City of	LA	605
12	Sonoma County	CA	604
13	Mibile, City of	AL	549
14	Galveston County	TX	544
15	St. Petersburg, City of	FL	533
16	Texas City, City of	TX	524
17	Peoria County	IL	516
18	St. Louis County	MO	498
19	East Baton Rouge Parish	LA	483
20	Montgomery County	TX	450
		TOTAL LOSSES	33,356

Source: Federal Insurance Administration, Office of Loss Reduction. "Summary and Assessment of National Flood Insurance Program (NFIP) Repetitive Loss Data." June 1990.

Repetitive losses and repetitive loss structures are not uniformly distributed across the Nation. The problem is largely concentrated in several states with histories of severe flooding. Repetitive losses tend to be more concentrated in a few states than do NFIP claims in general, and this is largely due to the significantly higher percentages of repetitive losses in the states of Louisiana and Texas. Twenty of the 54 states and territories have had fewer than 100 repetitive losses.

The repetitive losses appear to be concentrated in a relatively small number of the 18,000 communities participating in the NFIP. The top six repetitive loss communities have had 29.7 percent of all repetitive losses. The top twenty repetitive loss communities have had 44.3 percent of all repetitive losses. The top one hundred repetitive loss communities have had 66.2 percent (49,826 losses) of all repetitive losses. Although twelve of the top twenty repetitive loss communities would be considered coastal communities, in only two of these communities is there a significant number of flood insurance policies in effect in the coastal area. Even these two communities have extensive areas subject to riverine or stormwater flooding. Only 22 of the top 100 repetitive loss communities can be characterized as being primarily subject to tidal flooding. This tends to support the idea that the repetitive loss problem is more related to riverine or stormwater flooding than tidal flooding.

Community Rating System

The Federal Insurance Administration has established a Community Rating System (CRS) to encourage communities participating in the NFIP to undertake floodplain management activities that go beyond the activities required for program participation. As incentive, a reduction in flood insurance premiums will be provided for policy holders within communities that take approved action to reduce flood losses.

A multi-discipline task force was established in early 1987 to plan the development of the CRS. The task force recommended a preliminary set of community activities or activity elements that could be considered as a basis for rating. These activities were the subject of a field survey of approximately 200 communities conducted in 1988-1990.

Among the creditable activities are:

- More restrictive standards for new development;
- More restrictive standards for existing development;
- Community maintenance of FEMA elevation certificates;
- Required disclosure statements for floodplain properties;
- Public information programs;
- Programs to reduce repetitive losses;
- Maintenance of existing structural flood protection projects;
- Channel maintenance;
- Stormwater management programs;
- Sand dune maintenance and replenishment programs;
- Flood warning and response programs; and
- High risk flood hazard mitigation programs.

The purpose of the field survey program in 1988-90 was to examine programs in selected communities to determine difficulties in evaluating program effectiveness for flood loss reduction and to establish specific measurement criteria. Additional activities that might be suitable for the community rating system will be considered (MacKay, 1988).

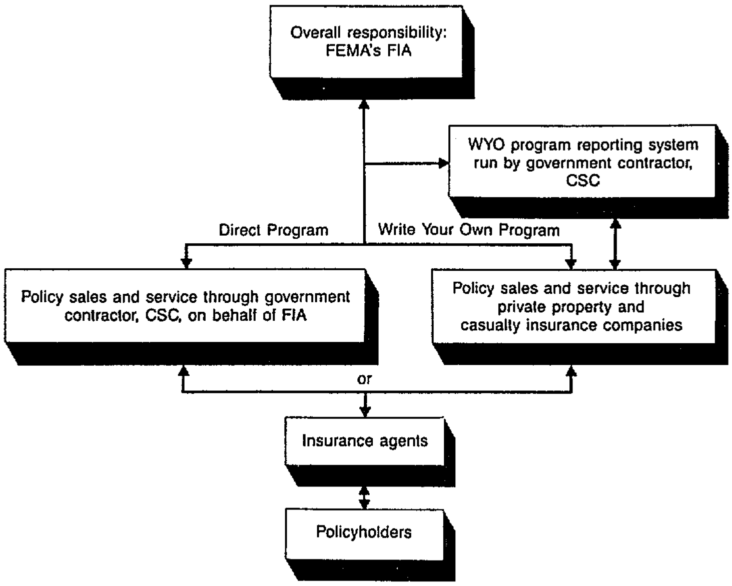
Sale of Flood Insurance

The National Flood Insurance Act (NFIA) provides that the NFIP can be operated by private insurance companies under federal direction, or that the program can be managed by the government itself. Until 1978 the program was operated through pools of private insurance companies. In 1978 the FIA eliminated the involvement of private insurance companies because of problems related to budgeting, contracting, and the FIA's regulatory authority. From 1978 until November 1983, only the FIA sold and serviced flood insurance policies, and did so directly through a contractor and insurance agents.

In 1981, the FIA began an effort to once again involve private insurance companies in the flood insurance program. Under this new effort — referred to as the Write Your Own (WYO) program — the FIA established a policy sales and servicing mechanism by which insurance agents could sell flood insurance policies through individual property and casualty insurance companies.

The WYO program arrangement is similar to the direct government sales program for flood insurance through which insurance agents have worked directly with a government contractor since 1978. The direct government sales program enabled insurance agents to sell policies under the NFIP name, service policies, and arrange for claims adjusters to visit and document reported losses. Agents receive a 15 percent commission for their expenses based on premiums collected for policies under the direct program. A contractor to the FIA handles the day-to-day operation of the direct sales and servicing aspects of the NFIP.

WYO companies sell insurance under their own names, collect premiums, and retain a percentage of the premiums as an allowance for commissions and other administrative expenses. Companies service their own flood insurance policies, inspect and document losses, and pay the claims arising from flooding of their policyholders' properties. When companies' paid claims exceed net premium monies on hand, the companies are reimbursed by the federal government through a letter-of credit. Thus, the companies bear no financial risk due to flood losses. The first WYO policy was sold in 1983. In 1984 the FIA arranged for agents to transfer or "rollover" policies from the direct program to designated WYO companies (U.S. General Accounting Office, 1987). As of 1987, about one-third of all flood insurance policies were sold through WYO companies, and the FIA expects increasing sales through the WYO program and decreasing sales through its contractor (Simmons, 1988). Figure 13-1 shows the organizational structure for sales and servicing of flood insurance policies.



Source: U.S. General Accounting Office. Flood Insurance: Private Companies' Participation in the Write Your Own Program. Report to Legislation and National Security Subcommittee, Committee on Government Operations. GAO/RCED-87-108, 1987.

Figure 13-1. Organizational Structure of the National Flood Insurance Program.

PRIVATE SECTOR FLOOD INSURANCE

The NFIP was authorized by Congress because flood insurance was typically not available through private insurers. Insurance companies had found that there was not enough information to determine actuarial rates and that, unlike fire, automobile, and most other types of insurance, flood insurance would only be purchased by those individuals and businesses with a high likelihood of being flooded. Today, flood insurance is still largely unavailable except through the NFIP. Some companies, however, do underwrite flood insurance. Lloyds of London-based policy, for example, has as many policy holders in Utah as the NFIP has. Some private policies or riders are available for basement flooding; these were initiated after the NFIP limited the coverage available for basements and the damage caused by subsurface flows. In addition, flood insurance is included as part of a comprehensive flood insurance policy for some large businesses with offices and land holdings in many locations in and out of the floodplain.

CROP INSURANCE

Crop insurance provides protection to agricultural producers from losses caused by unavoidable disasters such as insects, disease, fire, hail, drought, floods, freezing, and wind. The U.S. Department of Agriculture's Federal Crop Insurance Corporation (FCIC) is a government-owned corporation created in 1938 to promote the national welfare by improving the economic stability of agriculture through a sound program of federal crop insurance. The FCIC encourages the construction of dikes as well as other measures for emergency preparedness (Soil Conservation Service, 1989). Crop Insurance Program data on flood losses are not available.

EFFECTIVENESS OF FLOOD INSURANCE

Since the National Flood Insurance Program was authorized in 1968, the FIA has made significant progress toward increasing the number of structures insured on an actuarial basis and achieving a financially self-supporting program. During this time, the availability of flood insurance has greatly eased the financial trauma of flood damage for many thousands of property owners and renters.

Few question the desirability of a viable program of flood insurance. There are some questions, however, concerning the manner in which flood insurance is made available and the level of success that has been achieved in insuring the large number of structures subject to the one percent annual chance flood.

Because only a small percentage of floodprone structures are insured, and many structures are still insured at subsidized rates, the premium base is not large enough to permit the NFIP to operate on a fully actuarial basis. In addition, those structures covered by flood insurance tend to be the structures most at risk. FEMA has stated that it is interested in increasing the market penetration of flood insurance by at least 100 percent to reduce the financial suffering of disaster victims, spread the cost of flood losses, and provide additional mechanisms for postdisaster relief (Federal Emergency Management Agency, 1989). In an attempt to increase the market share, FEMA is aggressively pursuing the sale of flood insurance in areas outside the one percent annual chance floodplain. This strategy has been questioned by those who feel that insurance should not be made available in areas not subject to regulation.

Other methods for increasing the number of structures with flood insurance have been suggested, including stricter enforcement by lenders of mandatory purchase requirements, and maintenance of premiums at reasonable levels. The number of flood insurance policies has remained relatively constant for several years, yet new structures (most with federally insured mortgages) continue to occupy the floodplain and there is no evidence that the existing inventory of floodplain structures is significantly declining. Consequently, the number of flood insurance policies should be steadily increasing. It is not, however, and FEMA and others have noted that the federal lending institutions have not been diligent in requiring purchase of flood insurance as a mortgage condition, nor have they consistently required that the insurance, if purchased, be maintained. Various recommendations have been put forth to address this concern, including recommendations for new legislation.

Another approach for increasing sale of flood insurance is to increase awareness of the flood hazard. If lending institutions do not properly inform a buyer that a structure is floodprone, or if a federal financial institution is not involved, a new owner or renter may not be aware that a structure is located within the floodplain. To help reduce the number of persons who are uninformed or misinformed about the flood risk, disclosure requirements for realtors have been suggested. In only a very few areas of the country are realtors now required to notify prospective occupants if a structure is located in a floodprone area.

Not everyone is convinced, however, of the long-term benefits of making flood insurance available throughout the one percent annual chance floodplain. One view is that flood insurance should not be available in high risk areas such as floodways and V-zones. A more extreme view is that lending institutions should not be permitted to make any loans at all for property located in floodplains (Vessey, 1989). FEMA, however, prefers to make flood insurance available and to allow the high rates for vulnerable structures to serve as a deterrent to inappropriate development.

TAX ADJUSTMENTS

Tax adjustments at the federal, state, or local level can influence decisions about floodplain occupancy and can provide relief to individuals affected by a flood disaster. Tax provisions can be used to encourage appropriate floodplain use and discourage inappropriate use. Financial relief can be provided through provisions for claiming losses in federal and state income taxes and through special allowances on real estate taxes following a flood (Federal Interagency Floodplain Management Task Force, 1986).

FEDERAL TAX ADJUSTMENTS

The U.S. income tax was enacted in 1913 and the Internal Revenue Code was enacted in 1954. During the three decades prior to 1986, exclusions, itemized deductions, and deduction value of credits increased greatly and offset about 34 percent of personal income in 1982 as opposed to 18 percent in 1954. These exclusions and deductions became, along with the market, a major determinant of how economic resources were used, and the tax system exerted a pervasive influence on the behavior of private decision-makers (U.S. Department of the Interior, 1988). As noted by the Department of the Treasury:

> *The United States income tax is not used simply to raise revenue. Instead it is used to subsidize a long list of economic activities through exclusions from income subject to tax, adjustments to income, business deductions unrelated to actual expenses, deferral of tax liability, deductions of personal consumption expenditures, tax credits and preferential tax rates* (U.S. Department of the Treasury, 1984).

The Tax Reform Act (TRA) of 1986 made major changes in the Internal Revenue Code. These changes were in large part designed to reduce the code's interference with economic decisions made by individuals and businesses.

Casualty Losses

Prior to the TRA, all taxpayers were authorized to deduct any loss from fire, storm, flood, shipwreck, or other casualty or theft sustained during the taxable year and not compensated for by insurance or other means. The only limitation was that the aggregate amount of all such losses sustained by an individual was limited to the amount that exceeded 10 percent of the adjusted gross income of the individual (Section 165(c)(3) of the Internal Revenue Code). Development connected with a trade or business, and development conducted as transactions for profit by corporations, were also permitted to take casualty loss deductions (Section 165(c)(1) and (2) of the Internal Revenue Code). Section 165(i) allowed taxpayers to take certain disaster losses into account for the tax year immediately preceding the tax year in which the disaster occurred. These provisions had the effect of reducing the risk of financial loss for those who built in floodplains and other dangerous locations.

The TRA prohibited any deduction for individuals for the first $100 of any casualty loss. The casualty loss deduction is limited to the total amount lost in any year (reduced by $100 per casualty) in excess of 10% of the adjusted gross income. The $100 exemption and the 10 percent rule, however, do not apply to business property (Bernstein, 1987).

Development Incentives

Several provisions of the Internal Revenue Code provide incentives for development (casualty loss deductions also provide development incentives by removing a portion of the risk), while relatively few provisions provide incentives to leave land undeveloped.[5] No data have been found to provide insights into the magnitude of floodplain development that has resulted from tax code development incentives. The major tax incentives for development are summarized on the following page.

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[5] Tax incentives to leave land undeveloped are described in Chapter 14 of the *Assessment Report*.

- **Depreciation Allowances.** The Accelerated Cost Recovery System (ACRS) was established by the Economic Recovery Tax Act of 1981 and controlled depreciation allowances for tangible property placed in service after 1980. The ACRS assigned all "recovery property" to a class with a specified recovery period and depreciation schedule. The ACRS was one of the principle tax shelters available to investors and owners of real property placed in service after 1980. Its provisions greatly enhanced the internal rate of return, stimulated the growth of tax shelters, and provided powerful incentives for development. It also made possible the sheltering of an investor's unrelated income, deferred tax liability, and encouraged taxpayers to make investments that they otherwise would not make, in order to obtain tax benefits. The Tax Reform Act eliminated the ACRS and allows only straight-line depreciation of property over a longer time period.

- **Long-Term Capital Gains Deductions.** Prior to the TRA of 1986, gains or losses from the sale or exchange of capital assets held for more than six months (one year for assets acquired before June 23, 1984) were treated as long-term capital gains or losses and received preferential tax treatment. For individuals and other noncorporate taxpayers, 60 percent of net capital gain was excluded from income, with the balance of 40 percent taxable at ordinary rates. For corporations, the regular maximum tax rate was reduced to 28 percent on net capital gain if the tax computed using that rate was lower than the corporation's regular tax. The TRA eliminated long-term capital gains deductions.

- **Deductibility of Interest Expenses.** Interest expenses on loans to finance purchase of residential or investment property may be deducted. The TRA placed limitations on the amount of interest expenses that could be deducted.

- **Investment Tax Credits.** The TRA eliminated investment tax credits previously available to businesses.

- **At-Risk Limitations on Real Estate Holdings.** The amount of loss that an investor may deduct is limited to the amount of capital actually at risk. Prior to 1987 this limitation did not apply to real estate holdings or to limited equipment leasing by closely held corporations. Real estate and equipment leasing investors were thus allowed to offset taxable income with tax losses not matched by economic losses, guaranteeing an investor a return that might make an otherwise uneconomical investment feasible (U.S. Department of the Interior, 1988).

While the 1986 TRA did not eliminate all development incentives in the Internal Revenue Code, it placed major restrictions on many tax deductions and credits previously used to build in floodplains, on barrier islands, and in other hazardous locations, as well as in nonhazardous locations.

STATE AND LOCAL ACTIVITIES

Many states and communities provide some type of tax relief and development incentives (or disincentives) that have important floodplain management applications.

Casualty Losses

Following disastrous floods, many states and communities provide some type of tax relief. A community may reduce or temporarily suspend local real estate taxes or business taxes for individuals and businesses affected by flooding. States may do the same where real estate or other taxes are paid directly to the state. States may also provide for casualty deductions on state income taxes. Some states have provided reimbursement to communities for lost tax revenues.

Following disastrous flooding in June 1982, the State of Connecticut enacted special flood relief legislation that included a provision for tax abatements for persons whose property was damaged more than 10 percent of its value by the floods. Towns were authorized to abate up to one-third of the taxes due, and the state would reimburse the towns for 90 percent of the taxes lost. Eighteen towns offered some tax abatement to property owners, and the state reimbursed these towns a total of $49,504 (L.R. Johnston Associates, 1983).

Development Incentives

Many state and local tax codes are based on the federal Internal Revenue Code and so contain some of the same development incentives. In addition, state and local governments devise their own programs to provide tax incentives for business growth and development. Property taxes and sales taxes are the two most common means through which local governments (and many state governments) provide tax incentives. Techniques may include property tax reductions and abatement or deferral of taxes to entice or retain businesses. "Enterprise zones" or other special business areas may be established to promote development and employment opportunities in economically depressed areas. Special impact fees and assessments for services may also be used to help influence development decisions or to help offset government costs of development.

The City of Stamford, Connecticut has required developers of certain projects constructed in the floodplain to contribute funds for the operation and maintenance of the City's automated flood warning system (Emerson, 1988).

In a reverse treatment of taxes, in 1987, Des Plaines, Illinois initiated a permit surcharge of $200 for floodplain development projects to help finance city flood protection activities.

EFFECTIVENESS OF TAX ADJUSTMENTS

The extent to which the Tax Relief Act has actually reduced the influence of the U.S. Tax Code on economic decisions made by individuals with regard to floodplain development is unclear. Because most of the casualty loss provisions were retained, the tax code still provides financial aid to those suffering flood losses. While this may be a worthwhile social goal consistent with floodplain management concepts, some inconsistencies with sound floodplain management practices and other federal policies are evident.

For example, the Coastal Barrier Resources Act (CBRA) is intended to avoid federal subsidy of development on undeveloped coastal barriers, and most forms of federal financial assistance on coastal barriers are prohibited, including flood insurance. Yet, the availability of casualty loss deductions means that an individual can use private funds for development on property within the Coastal Barrier Resources System (CBRS) with limited financial risk from damaging floods. Availability of casualty loss deductions for structures within the one percent annual chance floodplain also appears to conflict with a number of floodplain management objectives and to actually weaken the effectiveness of the NFIP. An individual may locate in a floodprone area, not purchase flood insurance, and be eligible for casualty loss deductions in the event of a damaging flood. A more consistent approach would be to limit casualty loss deductions to property located outside the designated one percent annual chance floodplain (U.S. Environmental Protection Agency, 1989).

In general, it would appear that tax incentives and disincentives for influencing location and development decisions in floodprone areas have not been effectively used. For the most part, tax incentives at all government levels have been used to encourage development without regard to whether that development might occur in a hazardous location. Tax provisions to discourage development in hazardous areas appear to have been little used (Fuller, 1989).

FLOOD EMERGENCY MEASURES

Flood emergency measures are typically carried out by communities, supplemented as necessary by assistance from state emergency services agencies and federal agencies. Preparation for floods and establishment of flood fighting plans, including contingency and emergency floodproofing, can be completed in anticipation of flooding for areas where flood warning time permits. During and immediately after a flood, emergency activities may include emergency actions to remove people and property from areas that may be flooded; sandbagging around individual structures and constructing emergency dikes and other activities to direct floodwater away from vulnerable areas; search and rescue efforts during and immediately after flooding; and immediate postflood emergency measures to protect the health and safety of area residents. One of the functions of an overall program for floodplain management is to reduce the need for this type of emergency action (Federal Interagency Floodplain Management Task Force, 1986).

FEDERAL ACTIVITIES

The Corps of Engineers is the federal agency most commonly involved in flood emergencies. The Corps has authority under P.L. 84-99 to provide assistance to other agencies and to supplement local and state resources during a flood emergency. The Corps can furnish assistance for: flood emergency preparation; flood fighting; the repair and restoration of any flood control works threatened or damaged by a flood; provision of emergency supplies of clean drinking water for communities with water supply contaminated by a flood; advance measures to protect against flooding; and hazard mitigation to limit damage potential caused by future flood events. Assistance under P.L. 84-99 may include furnishing technical advice and assistance; furnishing flood fighting materials, such as sandbags, polyethylene sheeting, pumps, and riprap to stabilize eroding levees; hiring of equipment and operators for flood fighting operations; and removal of log or debris jams that are blocking stream flow and causing flooding of communities. During a flood emergency, the maximum use of local and state resources must first be made before assistance in the form of supplies and equipment can be provided by the Corps (U.S. Army Corps of Engineers, 1987).

The Federal Energy Regulatory Commission (FERC) requires emergency action plans (EAPs) for all its licensed dams, To provide comprehensive tests of the plans, licensees must hold periodic exercises, or in-depth tests, of their EAPs. These tests require the licensees to interact with state and local disaster agencies. The goal is to help licensees improve the EAPs so that they are clear, concise, and easily understood by evacuation agencies. The exercises promote cooperation between licensees and agencies, and develop the coordination vital to a successful response to a failure of a dam. To facilitate the exercise process, FERC conducts a two-day training seminar on EAPs.

The Soil Conservation Service may also become involved in flood emergency measures through its Emergency Watershed Protection Program, and specifically with regard to efforts to stabilize streambanks and prevent further erosion and flooding. The Emergency Watershed Protection Program is divided into two phases: Exigency Phase and Non-Exigency Phase. The Exigency Phase provides for temporary or permanent measures in areas where immediate action is needed to prevent further damage from occurring. The Non-Exigency Phase provides for stabilization efforts where there is no immediate threat of further damage if additional flooding were to occur.

Following widespread flooding in June 1982 in Connecticut, the Soil Conservation Service office in Connecticut contacted the SCS national office and requested immediate funding to permit exigency work to begin. The request was approved and additional SCS personnel were assigned to Connecticut from Rhode Island, Pennsylvania and Massachusetts. The SCS personnel immediately prepared designs for stream channel stabilization and let the first contracts for emergency work only 6 days after serious flooding began. Within one week, 20 contracts were awarded for work in 13 communities involving removal of trash, lumber, trees, homes and cars from stream channels. Stream banks were seeded to stabilize them, and thousands of tons of riprap were used on stream banks. Total costs of these emergency stream stabilization projects was $2,655,229, funded 100 percent by the SCS.

Several nonexigency projects were also undertaken by the SCS with 80 percent of funding from the SCS and 20 percent from the local sponsor — the Connecticut Department of Environmental Protection. Eighty sites were investigated by the SCS for possible treatment under the nonexigency program, and 25 were selected for treatment. Only 20 sites were ultimately included in the program, with work at the remaining five sites funded by the FEMA Public Assistance Program or directly by the town. Total cost of the projects was $800,083 (L.R. Johnston Associates, 1983).

Other federal agencies such as the Tennessee Valley Authority (TVA), Bureau of Land Management (BLM), Bureau of Reclamation (BOR), and Forest Service (FS) may become involved in flood emergency measures for floods occurring within their jurisdiction or on lands that they manage.

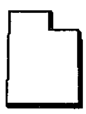
FEMA involvement during the emergency phase of flooding is primarily to assist state and local governments in assessing the extent and severity of damage in order to seek disaster assistance.

STATE AND LOCAL ACTIVITIES

State emergency services agencies generally coordinate state resources and activities during flood emergencies. State police, transportation or public works departments, and state national guard units typically undertake major roles during flood emergencies. Other state agencies, particularly those responsible for dam safety and water resources activities, may also become involved depending on the type and severity of flooding.

California published and distributes a nontechnical manual titled "Flood Fighting Methods" which includes basic information such as how to fill sandbags, and detailed discussions on types of levee failure and actions to prevent such failures. The State also offers courses on flood fighting to communities and the public. Illinois has prepared a similar manual called "Flood Fighting."

Most flood emergency measures are carried out at the local level. Local civil defense, police, fire departments, public works agencies, public health personnel, and most other local government personnel may become involved in emergency measures depending on the severity of the flooding. Experience has shown that most communities that are not flooded frequently remain inadequately prepared to deal with flood emergencies. The infrequency of major flooding (at least in most communities) appears to result in complacency and lack of preparedness.



In Utah, Salt Lake County and City experienced above normal precipitation and flooding in 1983. In early May the potential for severe flooding was apparent due to a large snowpack and unusually cold temperatures into the spring. The county began 24-hour monitoring of critical streams and personnel were shifted to staff flood control operations. The most vulnerable flooding location in the City was at 13th South where three streams came together. City forces, with assistance from volunteers, diked the street for use as a stream channel. Following a sudden thaw on May 26, the County and City declared an emergency status and flood control plans were placed in operation. Two days later another creek reached a flood discharge nearly double its previous record and went out of control. Volunteers were called in to sandbag 1.5 miles of State Street through the City. Flood waters were successfully controlled in a temporary river down State Street.

During the flooding period, volunteers provided an estimated 50,000 person days of effort in Salt Lake City and about twice that in the remainder of the County. The value of volunteer efforts during the period of flooding and cleanup afterwards was estimated at over $18 million. (Armstrong and Rosen, 1986).

PRIVATE SECTOR ACTIVITIES

The private sector is usually thoroughly involved with flood emergency measures. Activity may range from the individual who evacuates in anticipation of flooding and/or takes emergency measures such as relocating furniture or placing sandbags around a home, to the efforts of organized groups such as local chapters of the American Red Cross who may provide emergency food, shelter and other supplies. Private contractors play a major role in work for communities and individuals to remove debris, repair homes, roads, bridges, and other property damaged from floods. Some states and communities have entered into agreements with private contractors to provide emergency services in the event of a flood or other disaster. As illustrated by the example of the 1983 floods in Utah, volunteers, acting as individuals and as organized groups, often play a major role during flood emergencies.

EFFECTIVENESS OF FLOOD EMERGENCY MEASURES

The effectiveness of flood emergency measures depends in large part on the state of preparedness. Unfortunately, most communities that do not experience frequent flooding do not have well developed, up-to-date emergency plans with which essential personnel are familiar. Emergency response is therefore handicapped during the time of actual emergency. In many cases, this deficiency is offset by the abilities of local police, fire and public works departments with knowledge of local conditions as well as practical knowledge and experience with emergency situations.

DISASTER ASSISTANCE

Disaster assistance is provided by federal, state and local governments and the private sector. Assistance may be provided to repair, replace, or restore facilities damaged or destroyed by a disaster and to provide financial relief.

FEDERAL DISASTER ASSISTANCE

Federal disaster assistance is provided in varying degrees and for different types of emergency and rehabilitation activities after natural disasters. The greatest source of Federal disaster assistance is provided under the authorities of the Disaster Relief Act (P.L. 93-288, as amended), which is implemented by the Federal Emergency Management Agency following a Presidential declaration of a major disaster or emergency. In November 1988, P.L. 93-288 was amended by P.L. 100-707 and retitled the "Robert T. Stafford Disaster Relief and Emergency Assistance Act." FEMA administers grants to the states from the President's Disaster Relief Fund and directs and coordinates the disaster assistance functions of all federal agencies. In some cases, disaster assistance may be obtained from specific federal agencies such as the Small Business Administration or the Farmers Home Administration without a Presidential declaration of a major disaster or emergency.

Disaster Declaration Request Process

A federal declaration of a major disaster will be considered only at the request of the governor of the affected state or territory. When the governor determines that disaster recovery is beyond the capability of the state and local governments, he or she may request the President to declare a major disaster. FEMA regional office personnel, accompanied by state and local government representatives, then conduct on-site preliminary damage assessments. On the basis of information in the governor's request and information gathered during the damage assessment, the FEMA regional office prepares a regional summary and an analysis and recommendation for FEMA headquarters review. FEMA's State and Local Programs and Support Directorate decides on the proposed recommendation to be presented to the FEMA Director for transmittal to the President. The declaration package is prepared by FEMA and delivered to the White House for a final decision (U.S. General Accounting Office, 1989).

Major Disaster vs. Emergency

A "major disaster" as defined in the Stafford Act means:

> *any natural catastrophe (including any hurricane, tornado, storm, flood, high water, wind-driven water, tidal wave, tsunami, earthquake, volcanic eruption, landslide, mudslide, snowstorm or drought), or, regardless of cause, any fire, flood, or explosion, in any part of the United States, which in the determination of the President, causes damage of sufficient severity and magnitude to warrant major disaster assistance under this Act to supplement the efforts and available resources of States, local governments, and private relief organizations in alleviating the damage, loss, hardship or suffering caused by a disaster.*

An "emergency" is defined as "any instance for which, in the determination of the President, Federal assistance is needed to supplement State and local efforts and capabilities to save lives and protect property and public health and safety or to lessen or avert the threat of a disaster in any part of the United States."

After a Presidential declaration of a "major disaster," a broad range of assistance is made available to the community and to affected individuals. Federal assistance made available under a declaration of "emergency" is more limited in scope.

Under a major disaster declaration three general types of assistance may be authorized — Public Assistance, Individual Assistance, and hazard mitigation assistance. Federal funds for public assistance may be available to the disaster-affected community or to the state for both emergency and longer-term recovery activities, including:

- clearance of debris on public or private land or water;
- emergency protective measures for the preservation of life and property;
- repair or replacement of roads, streets, bridges, and water control facilities (dikes, levees, irrigation works, and drainage facilities);

- repair or replacement of public buildings and related equipment, public utilities, and public facilities damaged while under construction;
- repair or restoration of recreational facilities and parks;
- repair or replacement of private nonprofit educational, utility, emergency, medical, and custodial care facilities, including those for the aged or disabled, and facilities on Indian reservations;
- community loans from FEMA to those communities that may suffer a substantial loss of tax and other revenues and demonstrate a need for financial assistance to perform their governmental functions;
- repairs and operating assistance to public elementary and secondary schools; and
- use of federal equipment, supplies, facilities, personnel, and other resources (other than the extension of credit) from various federal agencies.

Specific funding for hazard mitigation measures is also available to state and local governments, and to eligible private nonprofit organizations through the Hazard Mitigation Grant Program. Requirements of this program are:

- up to 50 percent federal funding is available for mitigation measures;
- total federal mitigation funding is limited to 10 percent of the estimated public assistance grants for permanent restorative work;
- measures must be cost-effective;
- measures must be consistent with state and local hazard mitigation plans required as a condition of receiving federal disaster assistance; and
- measures can protect private or public property so long as they are eligible under Program guidelines.

A range of federal assistance is also made available to individuals affected by a major disaster, including:

- temporary housing, or essential repairs to owner-occupied residences in lieu of other temporary housing;
- disaster unemployment assistance;
- low interest loans for repair or replacement of damaged property;
- agricultural assistance, including technical assistance, payments to eligible farmers who perform emergency conservation actions on farmland damaged by the disaster, and provision of federally owned feed grain for livestock and herd preservation;
- distribution of food coupons to eligible disaster victims;
- individual and family grants of up to $10,400 to meet disaster-related necessary expenses or serious needs of those adversely affected by a major disaster;
- legal services to low-income families and individuals, consumer counseling and assistance in obtaining insurance benefits, and crisis counseling and referrals to appropriate mental health agencies to relieve disaster-caused mental health problems; and

- Social Security assistance for recipients or survivors, such as death or disability benefits or monthly payments, and veterans assistance, such as death benefits, pensions, insurance settlements, and adjustments to home mortgages held by the Veterans Administration if a VA-insured home has been damaged.

Federal assistance provided for declared "emergencies" is intended to meet specific needs and is generally limited to immediate actions to reduce the threat of a more severe disaster. This type of assistance includes:

- emergency mass care, such as emergency shelter, emergency provision of food, water, medicine, and emergency medical care;
- clearance of debris to save lives and protect property and public health and safety;
- emergency protective measures, including search and rescue; demolition of unsafe structures; warning of further risks and hazards; public information on health and safety measures; and other actions necessary to remove or reduce immediate threats to public health and safety, to public property, or to private property when in the public interest;
- emergency communications and emergency transportation; and
- emergency repairs to essential utilities and facilities as necessary to provide for their continued operation.

Federal Emergency Management Agency

FEMA administers grants for federal disaster assistance from the President's Disaster Relief Fund and directly coordinates the disaster assistance functions of all federal agencies. The state government, as a partner in the FEMA-state agreement signed after a Presidential disaster declaration, has specified responsibilities, including an important role in the disbursement of certain federal disaster assistance funds. As the coordinating federal agency, FEMA performs many services, including: establishment of a Disaster Field Office (DFO) as a base for all federal disaster assistance functions; establishment of one or more Disaster Application Centers (DAC) to help victims receive guidance, apply for assistance from various federal programs, and receive information regarding potential mitigation actions; conduct of briefings for state and local officials on procedures related to obtaining disaster assistance; and administration of FEMA's disaster assistance grants and loans as described previously (Federal Emergency Management Agency, 1982, 1984).

Other Federal Agencies

Although most federal disaster assistance is coordinated through FEMA, a few other federal agencies have disaster assistance programs that are provided separately from FEMA. Assistance from these programs may be available both with and without a Presidential declaration of a major disaster or emergency.

- **Small Business Administration.** The Small Business Administration (SBA) issues its own disaster declaration, separate from FEMA. SBA makes low-interest Physical Disaster Loans available directly to eligible individuals and businesses to replace or repair damaged real estate, inventory, or other business property. Businesses are required to document their flood damages and have the damages verified by an SBA representative, and all SBA loan recipients must demonstrate an ability to repay the loan. In addition to Physical Disaster Loans, the SBA offers Economic Injury Disaster Loans to businesses that suffer economic injury as a direct result of the disaster (with or without physical damage) and cannot obtain commercial credit. Application for SBA loans must be made within 180 days of the SBA disaster declaration.

Prior to 1988, loans could be made for up to 85 percent of the verified losses. P.L. 100-590 authorized the SBA to provide mitigation funding for all physical disasters declared on or after August 1, 1988. A physical disaster loan may be increased by an amount up to 20 percent of the loan to provide necessary or appropriate mitigation measures. The measures must be designed to protect against the same kind of disasters that caused the damage and may include building retaining walls and seawalls, grading and contouring of land, relocation of utilities, and modifying structures.

- **Federal Highway Administration.** The Federal Highway Administration (FHWA) administers the Emergency Relief Program in extending aid to State highway agencies to pay unusually heavy expenses of repairing serious damages to federal-aid highways resulting from natural disasters or catastrophic failures. The federal share is 90 percent for Interstate highways and 80 percent, in most instances, for other federal-aid highways. The federal share for emergency repairs to all federal-aid highways accomplished within 180 days of a natural disaster or catastrophic failure is 100 percent."

- **Soil Conservation Service.** Under the Emergency Watershed Protection Program, the U.S. Department of Agriculture's Soil Conservation Service may directly undertake emergency work for clearing debris from channels and stabilizing streambanks. Typically, SCS personnel prepare all plans and designs and supervise the work performed by contractors. Stream modification work that must be undertaken immediately to reduce the likelihood of further damage is authorized under an Exigency Phase, and is funded 100 percent by the SCS. Needed stream modification work not required immediately due to the threat of further damage is authorized under a Non-Exigency Phase, which is funded 80 percent by the SCS and 20 percent by a local sponsor. A municipality or a state agency may serve as the local sponsor.

- **U.S. Army Corps of Engineers.** The Corps has authority to provide several types of flood disaster assistance, including assistance for: disaster preparedness, advance measures, flood response, postflood response and rescue work, rehabilitation of flood control works damaged or destroyed by flood, protection or repair of federally authorized shore protection works threatened or damaged by coastal storms, and provision of emergency drinking water.

- **Farmers Home Administration.** Emergency Loans for agriculture may be made to farmers, ranchers and oyster planters in areas designated as eligible by the FmHA State Director under delegated authority.

- **Agricultural Stabilization and Conservation Service.** Under the Emergency Conservation Program, the Agricultural Stabilization and Conservation Service (ASCS) State Director may designate areas eligible for cost-sharing grants of up to 64% to rehabilitate farm lands damaged by natural disasters.

Significant Changes in Federal Disaster Assistance

Historically, the federal programs for disaster assistance have been oriented to provide financial and direct assistance for emergency response actions for short- and long-term recovery. These programs were designed to speed the return of the community to its predisaster condition. In the past twenty years, however, applicants for disaster assistance (communities and individuals) have had to comply with changing requirements and conditions to be eligible for disaster assistance, including requirements and conditions related to environmental protection, floodplain management and flood insurance, and hazard mitigation. In addition, there have been institutional changes in the disaster assistance delivery system, as well as changes in specific programs available to victims of disasters.

- **Institutional Changes.** The first major federal disaster relief legislation was enacted in 1950. Subsequently, a number of other federal agency disaster assistance programs were established. It was not until the mid-1970s, however, that the federal programs were coordinated and organized into a comprehensive effort. The major piece of legislation that consolidated and reorganized the disaster assistance provided by federal agencies was the Disaster Relief Act of 1974 (P.L. 93-288). Responsibility for coordinating disaster relief was assigned to the Federal Disaster Assistance Administration (FDAA), under the Department of Housing and Urban Development (HUD). When FEMA was established in 1979, the FDAA was reorganized as a component of FEMA.

- **Hazard Mitigation Opportunities and Incentives.** Since 1979, several changes have been made to federal disaster assistance programs in an attempt to increase postdisaster mitigation measures and reduce vulnerability to damages from future disasters. Policy changes now allow funding options for disaster assistance. In addition, planning requirements have been established and technical assistance made available for hazard mitigation.

  Two important nonfunded postdisaster mitigation activities are the Interagency Hazard Mitigation Team process and the requirement under Section 409 of the Stafford Act that state and local governments prepare postdisaster hazard mitigation plans. The Interagency Hazard Mitigation Teams are comprised of interagency, intergovernmental, and interdisciplinary teams of individuals that convene after a flood disaster to seek immediate opportunities for mitigation. These teams often identify mitigation issues to be addressed in the postdisaster mitigation plans that state and local governments are required to prepare as a condition of receiving federal disaster assistance. These state and local plans, in turn, help identify projects to be funded under the Hazard Mitigation Grant Program described earlier. The Interagency Teams and the Section 409 planning requirement are described in greater detail in Chapter 11.

Since 1982, federal funds for public assistance generally provide for reimbursement of 75% of the cost of repairing or rebuilding public facilities to predisaster conditions. In recent years, FEMA policies have been revised to allow state and local governments to undertake mitigation actions during disaster recovery. These funding options include:

- Authorization of cost-effective hazard mitigation measures to make a damaged public facility more disaster resistant.
- Funding for an "improved project," consisting of financial assistance totaling 75% of the estimate for restoration of a damaged facility to build a better or larger facility.
- Funding for an "alternate project" to perform approved work projects or construct new public facilities rather than to restore damaged public facilities.

The Robert T. Stafford Disaster Relief and Emergency Assistance Amendments of 1988 (P.L. 93-288 as amended by P.L. 100-707) made a number of important changes to existing disaster relief programs, including:

- Hazard mitigation is added as an eligible item under the Disaster Preparedness Improvement Grant Program (DPIG). The funding level for the DPIG is increased from $25,000 to $50,000 per state.

- A separate hazard mitigation funding program is established to fund 50% of the cost of measures that "substantially reduce the risk of future damage, hardship, loss or suffering." Such measures must be identified in a hazard mitigation plan prepared in accordance with Section 409 (formerly Section 406) and are subject to approval by the President. The maximum federal funds available are 10% of the estimated public assistance grants for permanent restorative works.

- If a community or private nonprofit agency decides not to rebuild a destroyed or damaged facility, 90% of the federal share for reconstruction is made available for other activities that include hazard mitigation measures. This is termed an "alternate project."

- Within 90 days of passage of the bill, any property owned by a governmental agency or private, nonprofit organization and located in a special flood hazard area damaged by flooding would not receive full federal disaster assistance. The amount received would be reduced by the value of the facility on the date of damage or by the maximum amount of flood insurance that can be purchased to cover that facility.

- Damages identified under floodplain management and hazard mitigation criteria are considered as eligible costs for federal funding for repair or reconstruction of public or private nonprofit facilities.

Disaster Assistance Payments

From 1965 through 1989 the President declared 657 major disasters under Public Law 93-288, of which 508 (77 percent) were related to floods and hurricanes. Total obligations from the Disaster Relief Fund for these disasters was $6,767,440,000, of which $5,205,540,000 (77 percent) was for disasters due to floods and hurricanes (refer to Table 3-13 in Chapter 3).

STATE AND LOCAL ACTIVITIES

For the most part, state and local governments rely on the federal government and the private sector to provide financial assistance after disasters. While all state and most local governments have some type of program to coordinate and provide assistance during the flood emergency, few have set aside any special fund to offer financial assistance to flood victims.

Disaster assistance by state governments varies greatly. As shown in Table 13-16, most states limit their own disaster assistance funding to local governments, rather than to individuals or businesses. All states now contribute some of the nonfederal share of assistance for Presidentially declared disasters. For example, several states will provide 12.5 percent of the matching funds required for federal aid. States may obtain this funding by issuing bonds or allocating funds from existing budgets (Association of State Floodplain Managers, 1988).

In 1982, flooding in Connecticut resulted in a Presidential disaster declaration for the southern half of the State. The State declared its northern half as a disaster area and provided financial assistance to local governments. The State paid for 75% of the cost of rebuilding public facilities in the areas not eligible for FEMA's Public Assistance funds (L.R. Johnston Associates, 1988).

States may also declare their own emergencies or disasters. No systematic data are available on state-declared emergencies or disasters, but twenty-eight states provide assistance to local communities, usually out of a governor's emergency fund, in the event of a state-declared disaster. In some cases financial assistance has been provided through special appropriations.

Table 13-16 shows those states that provide financial assistance to recovering individuals and families and to businesses. Not shown are the states that provide technical advice. Many of the states' homeowner publications include advice on clean up, financial assistance, how to deal with contractors, and other important postdisaster information (Association of State Floodplain Managers, 1988).

Local governments may provide disaster assistance to their residents and business community. Perhaps the most common method for local governments to provide disaster assistance is through some form of tax break for those affected by the flooding. Many local governments have joined in mutual aid agreements whereby they agree to assist nearby communities through provision of equipment, manpower and other means.

PRIVATE SECTOR ACTIVITIES

As shown in Table 13-17, a number of national level voluntary organizations provide a variety of disaster relief services, primarily emergency assistance for shelter, food, clothing, and medical aid. Longer-term assistance — for rebuilding homes or for job placement, for example — is also provided by some organizations. A committee known as the National Voluntary Organizations Active in Disaster coordinates a group of 11 disaster relief groups. Three of these organizations — the American National Red Cross, the Salvation Army, and the Mennonite Disaster Service — were formally recognized in the Disaster Relief Act of 1974 and have signed memoranda of agreement with FEMA regarding their disaster assistance activities (National Science Foundation, 1980).

Table 13-16. Disaster Assistance Provided by States.

	ASSISTANCE TO GOVERNMENTS	ASSISTANCE TO INDIVIDUALS	ASSISTANCE TO BUSINESSES
Alabama			
Alaska	X	X	
Arizona	X	X	
Arkansas			
California	X	X	
Colorado	X		
Connecticut	X		
Delaware			
District of Columbia	N/A	X	X
Florida	X		
Georgia			
Hawaii	X	X	X
Idaho			
Illinois			
Indiana	X		
Iowa	X		
Kansas	X		
Kentucky			
Louisiana			
Maine		X	X
Maryland	X	X	X
Maine			
Michigan	X	X	X
Minnesota	X		
Mississippi			
Missouri	X	X	
Montana	X		
Nebraska		X	
Nevada	X		
New Hampshire	X		X
New Jersey			
New Mexico	X		
New York	X	X	X
North Carolina	X	X	
North Dakota	X		
Ohio	X		
Oklahoma			
Oregon			
Pennsylvania	X		
Rhode Island			
South Carolina	1	1	1
South Dakota	X	X	X
Tennessee			
Texas	X		
Utah	X	X	X
Vermont			
Virginia			
Washington			
West Virginia	X	X	X
Wisconsin			
Wyoming	X		

1 South Carolina has never had a Presidentially declared flood disaster. From the State's response to other types of disasters, it is assumed that assistance would be made available.

Source: Association of State Floodplain Managers. "State Floodplain Management Programs. Results of a Survey Conducted by the Association of State Floodplain Managers for L.R. Johnston Associates," 1988.

Table 13-17. Private Organizations Providing Disaster Assistance.

	Volunteers of America	The United Presbyterian Church, U.S.A.	United Methodist Committee on Relief (UMCOR)	Southern Baptist Convention	Society of St. Vincent de Paul	Seventh-day Adventist Community Services	The Salvation Army	REACT International, Inc.	Presbyterian Church in the United States	National Conference of Catholic Charities	National Catholic Disaster Relief Committee	National Association for the Advancement of Colored People	Mennonite Disaster Service	Lutheran Council in the U.S.A.	The Episcopal Church	Church World Service	Church of the Brethren General Board	Christian Reformed World Relief Committee	Boy Scouts of America	B'nai B'rith	Ananda Marga	ARRL (The American Radio Relay League, Inc.)	The American National Red Cross
Professional Staff	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Trained Staff	X	X	X	X	X	X	X	X	X	X	X	I	X	X	X	X	X	X	X	I	X	X	X
Trained Volunteers	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	I	X	X	X
Untrained Staff	X	X	X	X	X	X	X	I	X	X	X	X	I	X	X	I	X	X	X	I	X	I	X
Untrained Volunteers	X	X	X	X	X	X	X	I	X	X	X	I	X	X	X	I	X	X	X	X	I	I	X
Facilities for Stationary Feeding	X	X	X	X	X	X	X	I	X	X	X	I	I		X	I	X	X	X	I	I	I	X
Equipment for Mobile Feeding	X	I	X	X	X	X	X	I	I	I	I	I	I		I	I	I	X	X	I	I	I	X
Mass Shelter Facilities	X	X	X	X	X	X	X	I	X	X	X	I	I	X	X	I	X	X	X	I	I	I	X
Trucks	X	I	I	X	X	X	X	X	I	I	I	I	X		I	I	I	X	X	I	I	X	X
Vans	X	X	X	X	X	X	X	X	X	I	I	I	X		X	I	I	X	X	I	I	X	X
Buses	X	X	X	X	X	X	X	X	X	I	I	I	X		X	I	I	X	X	I	I	X	X
Station Wagons	X	X	X	I	X	X	X	X	X	I	I	I	X		X	I	I	X	X	I	I	X	X
Rescue Equipment	X	I	I	I	X	X	I		I	I	I	I	I		I	I	I	I	X	I	I	I	X
Communication Equipment	X	I	I	X	I	X	X	X	I	I	I	I	X	X	I	I	I	X	I	I	X	X	X
Clothing	X	X	X	X	I	X	X	I	X	X	X	I	I	X	X	X	I	X	X	I	X	I	X
Bedding	X	X	X	X	X	X	X	I	X	X	X	I	I		X	X	I	X	X	I	X	I	X
Used Furniture	X	X	X	I	X	X	X	I	X	X	X	I	I		X	I	I	X	X	I	X	I	I
Materials for Rebuilding Homes	X	X	X	I	I	I	X	I	X	I	I	I	X	X	X	I	I	X	X	I	I	I	X
Collection and Distribution of Donated Goods Other Than Clothing	X	X	X	X	X	X	X	I	X	I	I	X	I	X X	X	I	I	X	X	X	I	I	I
Collection, Sorting, Sizing of Used Clothing	X	X	X	X	X	X	X	I	X	I	I	X	I	X	X	I	I	X	X	X	I	I	I
Cleaning Debris From Private Property	X	I	X	X	X	X	I	I	I	I	I	I	X		I	I	X	X	X	X	I	I	I
Cleaning Homes	X	X	X	X	X	X	I	I	X	I	I	I	X	X	X	I	X	X	X	X	I	I	I
Free Labor To Repair or Rebuild Homes	X	X	X	X	X	X	I	I	X	I	I	I	X		X	I	X	X	X	I	I	I	I
Welfare Inquiry Service	X	I	I	X	X	X	X	I	I	I	I	I	I	X	I	I	I	X	X	I	X	X	X
Registration and Information Service	X	X	X	X	X	X	X	I	X	I	I	I	I	X	X	I	X	X	X	I	X	I	X
Counseling Service	X	X	X	X	X	X	X	I	X	X	X	X	X		X	I	I	X	X	I	X	I	X
Capability To Handle Crisis Intervention and Long-Term Recovery	X	X	X	X	X	I	X	I	X	X	X	I	I	X X	X	I	I	X	X	I	I	I	I
Training	X	I	X	X	X		X		I	I	I		I	B	I		I	X	I	I		I	X
Financial Assistance	X	X	X	X	X	X	X	I	X	X	X		I		X	X	I	X	X	I	X	I	X
Comments	G			E	F	D	C						B				B	B					A

COMMENTS: A — Congressional mandate. If no other resource, the Red Cross will meet needs.
B — Expertise in establishing interfaith organization.
C — Bulk food distribution; warehousing ready supplies.
D — Private mobile homes available for major disasters.
E — $50,000 revolving fund; more if needed.
F — May be only in one or a few larger councils.
G — Ambulances and air transportation and rescue.

Source: Federal Emergency Management Agency. Integrated Emergency Management Course. Emergency Management Institute, 1983.

In addition to the organizations that operate nationally, local churches and other voluntary groups often have a significant role in supplementing the disaster assistance offered by the larger organizations.

American National Red Cross

The American National Red Cross was chartered as a national disaster relief agency by Congress in 1905. Before federally funded disaster assistance programs became extensive in the late 1950s and mid-1960s, the Red Cross played the primary role in providing disaster relief. After federal disaster assistance was expanded to include SBA disaster loans for flood victims, Farmers Home Administration (FmHA) loans, unemployment assistance for disaster victims, and other programs, Red Cross assistance focused more on mass care and emergency assistance, supplementing available federal programs and providing services in disasters where governmental programs were not available (i.e., where there was not a Presidential Declaration of Major Disaster).

The Red Cross functions through a national office, three operations headquarters, and over 2,800 local chapters. Disaster assistance provided by the Red Cross includes assistance for: damage assessment; emergency shelters; registration; communications; first aid personnel and stations; distribution of emergency supplies; stationary and mobile facilities for feeding victims and emergency workers; medical and nursing aid; blood and blood products; welfare inquiries and information services; emergency financial assistance for food, clothing, rent, bedding, selected furnishings, transportation, medical needs, temporary home repairs, occupational supplies, and other essentials on an individual or family basis; referral service to government and private agencies; casework services to provide additional recovery assistance to families where governmental programs are not available; and other recovery assistance when no resources are available.

From January 1974 to December 1979, Red Cross aid to flood victims totaled $63,415,000 (National Science Foundation, 1980).

Salvation Army

Operating through state and regional headquarters and community centers throughout the country, the Salvation Army provides disaster services similar to those of the Red Cross. The Salvation Army offers spiritual counseling, family counseling and casework services, registration and identification of victims services, missing-persons services, temporary shelter and feeding in Salvation Army institutions or temporary facilities operated as shelters, and mobile feeding for disaster victims and emergency workers. The Salvation Army also collects and distributes food, clothing, furniture, bedding, cleaning supplies, medical supplies, building materials, tools and utensils, and other items, and provides medical assistance and other services as needed.

Mennonite Disaster Service

The Mennonite Disaster Service is involved with cleanup and debris removal after natural disasters, with temporary and permanent repairs to private properties for the elderly and under-insured, and with rebuilding and reconstruction for low-income, poverty-level families, disadvantaged minorities, widows, and handicapped families.

Other Organizations

In addition to the major organizations, several other organizations provide disaster relief services:

- **Ananda Marga Universal Relief Team (Amurt).** This organization operates through its national headquarters in Washington, D.C., regional coordinators and disaster teams, and 100 local units. Its principal functions in a disaster are shelter management, survey, casework, stockpiling of clothes and food, teaching first aid, starting clinics, and distribution of food and clothing.

- **Christian Reformed World Relief Committee.** This committee consists of a synodical board of the Christian Reformed Church, based in Grand Rapids, Michigan. Volunteers include trained caseworkers who serve as supplemental staff to the Red Cross in working with disaster victims, as well as persons skilled in the building trades, including contractors, carpenters, electricians, and plumbers. The committee also assists local church groups in setting up an organization to carry out a long-term community relief program.

- **Church of the Brethren General Board.** The church disaster response coordinators operate through 22 districts, and local congregations are encouraged to have coordinators organize the parish for disaster response. The disaster response capability of the church varies with the strength and commitment of the districts. Some districts provide immediate response and long-term rebuilding assistance, while others engage only in the immediate cleanup phase. Initiation of response is from local congregations or districts, with General Board support when a specific disaster is beyond local and/or district capability. Emphasis is on assistance to the poor, elderly, and handicapped for longer-term relief and reconstruction.

- **Goodwill Industries of America.** This organization's disaster response involvement consists of making available physical facilities and equipment, such as food service, transportation, warehousing, and communications — used by the Red Cross by local mutual agreement. Emphasis is on developing and maintaining programs for the handicapped.

- **Society of St. Vincent De Paul.** The Society's disaster response services include volunteer person-to-person service, emergency assistance by parish units, and social services, depending on local needs and available resources.

- **National Catholic Disaster Relief Committee.** If disaster needs exceed resources of local Catholic Charities Offices, consultants may go to the affected area to advise the local church authorities. Volunteers are recruited as needed, and some immediate financial help may be available from the committee's small emergency reserve. If the disaster is of major proportion and large-scale help is needed, the Committee may launch a national appeal through the local dioceses.

- **Seventh-Day Adventists Community Services.** Disaster response services include: receiving, processing, and distributing clothing, bedding, household supplies and food; emergency feeding and counseling services; and emergency health care where professional personnel are available.

- **Southern Baptist Conventions Home Mission Board.** The principal services provided by the Home Mission Board in a disaster are funding and manpower services, usually working closely with the Red Cross. The Home Mission Board in Atlanta has a $100,000 unrestricted revolving fund for disaster relief.

- **Volunteers of America.** Volunteers of America provides initial services to meet the critical needs of disaster victims through a variety of programs and facilities. Personnel are trained for casework and shelter management, and fleets of trucks and special-service vehicles are available to transport supplies and victims to emergency shelters using the personnel of the Volunteers of America's men's rehabilitation centers. Food, shelter, and clothing, equipment for field canteens and special air flight services are also provided.

EFFECTIVENESS OF DISASTER ASSISTANCE

Recent research indicates that local governments have the capacity to assume a much higher proportion of losses than they typically do within the context of current federal and state disaster relief policies. These same studies indicate that because of the area-wide character of current relief policies, a relatively large proportion of governments (two-thirds of those experiencing losses between 1980 and mid-1987) receive federal assistance for relatively minor (under $50,000) losses. Conversely, governments experiencing losses in disasters not covering broad areas and not resulting in a Presidential declaration do not receive federal aid, even though their losses can be much larger than those experienced by the majority of local governments receiving aid in Presidentially declared disasters (Burby, 1989).

Following Hurricane Hugo in September 1989 (and the Loma Prieta earthquake in October), the U.S. General Accounting Office (GAO) conducted a review of the federal government's response to these two large disasters. In a preliminary report, the GAO noted that, historically, in an "average" disaster about 2,000 individuals and families seek federal disaster assistance and FEMA spends about $10 million (U.S. General Accounting Office, 1990). During the Hurricane Hugo and Loma Prieta earthquake disasters, about 375,000 individuals and families sought disaster assistance, and estimated expenditures from the President's Disaster Relief Fund for these disasters alone amounted to $2 billion. Although the GAO had not reached any final opinions at the time its preliminary report was released, it did report apparent coordination difficulties and uncertainty about the roles and responsibilities among the agencies involved in disaster relief.

Notwithstanding the apparent problems that occurred following Hurricane Hugo, and the inevitable confusion, uncertainty and stress following any disaster, delivery of disaster assistance through a variety of federal programs is largely efficient and adequate to provide the necessary financial relief to individuals and communities. In fact, disaster assistance has been viewed by many floodplain managers as so efficient that it negates many potential opportunities to undertake hazard mitigation following a flood (see the following section on Postflood Recovery).

Many forms of federal disaster assistance are not available to property owners in the Coastal Barrier Resources System and it is not clear if purchasers of these properties are aware of this situation (U.S. Environmental Protection Agency, 1989).

POSTFLOOD RECOVERY

Postflood recovery consists of any activity to actually recover from the damaging effects of flooding. Recovery actions are typically carried out by the individual, community, or other entity directly affected by the floods. Recovery may be aided by the several forms of disaster assistance discussed in the preceding section on Disaster Assistance. Recovery has traditionally been undertaken with the goal of restoring a community to its preflood condition — leaving the community just as vulnerable to flood damages as it was before the recovery. In more recent years, efforts have been made to at least partially break the "vicious circle" of flood disaster followed by disaster assistance to aid recovery, followed by yet another flood disaster, and so on. Undertaking recovery that reduces vulnerability to floods requires choices involving the entire range of floodplain management tools described in chapters 11, 12, and 13. Ideally some type of plan should be prepared in anticipation of a flood, and this plan should guide community recovery actions to mitigate the flood hazard. Such plans, however, are seldom prepared.

FEDERAL ACTIVITIES

Federal involvement in postflood recovery consists principally of providing financial aid and technical assistance for recovery and mitigation as described previously in this chapter. Recovery actions are also linked to disaster preparedness activities such as preparation of disaster preparedness plans and recommendations for flood hazard mitigation described in Chapter 11.

STATE AND LOCAL ACTIVITIES

As with federal activities, many state and local activities for disaster recovery are tied to disaster assistance and preparedness requirements and efforts described elsewhere in the *Assessment Report*. Where mitigation has been part of the recovery effort, many floodplain management tools have been used, including floodproofing, acquisition of damaged properties, and regulations. The following prominent examples illustrate state and local efforts for postflood recovery.

An extensive recovery effort followed the Big Thompson Canyon flash flood in Colorado:

The Big Thompson Canyon flash flood in Colorado in July 1976 caused property damages of $43 million ($16 million private and $27 million public) and resulted in 139 deaths. Following a 10-inch rain in a four hour period (on already saturated soils), an 18-foot high wall of water roared through the canyon without warning, sweeping away retirement cabins, vacation and year-round homes and destroying public roads. Colorado state law authorized the local adoption of moratoria for up to six months in emergency situations. The Larimer County Commissioners imposed such a six-month moratorium on rebuilding of homes that were more than 50 percent damaged in the flood.

The moratorium provided an opportunity for local and state officials to complete a floodplain study to ensure safer redevelopment. Floodplain regulations adopted for one area of the county in 1974 were evaluated for their applicability to the rest of the canyon area. Despite strong public opposition, the Big Thompson maps were added to the floodplain regulations (primarily to secure recovery assistance). In addition, an acquisition program was developed to acquire floodway lands in the canyon for public open space.

The revised floodplain regulations prohibited rebuilding in the floodway where homes were more than 50 percent damaged. Funds were obtained to acquire these properties from a number of sources (including Colorado Land and Water Conservation funds, state appropriations, the Four Corners Commission, Department of Interior Discretionary Fund, and HUD relocation and rehabilitation grants). Acquisition began to take place in December 1977; eventually 114 parcels were acquired from 94 property owners at a cost of $1.5 million. (The original estimate was for $2.5 million to acquire 364 parcels.)

Major problems in the Big Thompson recovery effort were delays and uncertainties. Obtaining funding for the acquisition program was a lengthy process, and purchases of damaged properties did not begin until 17 months after the flood. Also, there was political pressure to rebuild damaged and destroyed homes because of the lack of timely incentives for mitigation.

Still, the moratorium did provide some "breathing space" — time to focus on the immediate emergency needs and short-term recovery activities, to identify and assess damages, and to make a plan for a safer long-term recovery and redevelopment (Thayer, 1985).

The State of Alabama provides an example of postflood recovery in a coastal setting:

Hurricane Frederic, which struck the coast of Alabama on September 12, 1979, was one of the most physically destructive storms ever to hit the Gulf coast with water elevations up to 15 feet above mean sea level and winds of up to 145 miles per hour. In Gulf Shores, the one incorporated municipality on Pleasure Island which received the most severe damage along the coast, destruction was nearly total. Ninety percent of the first two tiers of development were either totally destroyed or severely damaged and insurance claims amounted to over $16 million. Damage to natural systems was also extensive (including flattening of dunes and shoreline erosion up to 100 feet) and the tourist-based economy was devastated. Total damages were estimated at $28.4 million.

Although Gulf shores had taken steps to prepare itself for storm damages through participation in the NFIP, adoption of the Southern Standard building code and a flood control ordinance, and revision of its zoning ordinance, much of the shorefront development predated these measures.

Following the storm and a Presidential disaster declaration, many residents, business people and local officials pressed for a quick reconstruction, to get things back to normal as fast as possible. New building and zoning regulations, however, as well as federal and state requirements for disaster assistance and reconstruction, were significant factors in the recovery process. Despite intergovernmental conflicts and development pressures, a temporary moratorium on redevelopment was imposed and some damaged properties were acquired (five parcels were acquired using FEMA's Section 1362 Flooded Property Acquisition Program and three parcels with Town funds and matching funds from the Department of Interior).

Although many opportunities for long-range hazard mitigation were missed (e.g., relocation of the damaged beach highway), the recovery process did involve strengthening the community's buildings (through application of the building code), and allowed for a more orderly redevelopment than might have occurred otherwise.

Despite a number of advances in its development procedures and a successful economic recovery, in many ways Gulf Shores is not prepared for a next hurricane. The higher density development that occurred after Hurricane Frederic has changed the nature of the hazard problem by increasing the number of seasonal residents that could be exposed to a severe storm. In addition, although community leaders have explored ways to increase evacuation capacity, as of 1984 the evacuation plan was inadequate for peak season evacuation (Brower, 1986).

Nags Head, North Carolina is one of the few communities that has prepared a plan specifically addressing postflood recovery:

The Town of Nags Head is a resort community facing substantial growth on the Outer Banks of North Carolina. This growth has created new problems for a formerly quaint village of seaside cottages. In addition to protecting the quality of its natural resources, how should it best prepare its residents and thousands of visitors for hurricanes and coastal storms?

The North Carolina Coastal Area Management Act Program (CAMA) provided some direction. The program mandated local land-use planning in 1974 and now requires local plans to include a poststorm policy section. The section must include a prestorm mitigation program, evacuation plans, and poststorm reconstruction policy.

In developing its mitigation plan, Nags Head surveyed all properties at risk. The survey found 84% of the Town's 2,500 buildings to be in the one percent annual chance floodplain and 44% of them in the high hazard areas. High hazard areas were identified as being within 300 feet of the ocean and V-zones. Also located in the one percent annual chance floodplain were four public buildings, 27 miles of street, and 32 miles of public water mains.

Following a series of meetings and workshops, the Board of Commissioners adopted policies and implementing actions "to reduce, to the extent possible, future damage from hurricanes and severe coastal storms." Nags Head's plan for responding to the hazards was divided into four phases: prestorm mitigation, warning and preparedness, response, and recovery and reconstruction.

Of particular interest to floodplain managers are some of the mitigation and reconstruction policies. There are twelve mitigation policies, including a policy to use the capital improvements program to encourage growth away from high hazard land, and a policy opposing construction of finger canals and other projects that destroy the protection provided by natural features.

The twelve poststorm reconstruction policies are designed to take advantage of the natural land clearance provided by severe storms to redevelop the Town. The Town will limit reconstruction of substantially damaged buildings and public utilities, will rebuild public structures strong enough to be used as shelters, and will not permit oceanfront reconstruction until the CAMA setback line is re-established (Williams, 1988).

EFFECTIVENESS OF POSTFLOOD RECOVERY

Postflood recovery efforts, aided by many types of disaster assistance, have been largely effective at restoring flood-damaged communities and individual properties to their preflood condition. The very effectiveness of the effort has meant that implementation of mitigation actions has not been very effective during the recovery period. Until the 1980s, relatively little attention was given to the need for postflood mitigation, and all attention was on recovery to preflood conditions. Throughout the 1980s, recommendations were made to modify recovery efforts so that mitigation actions could also be taken. Most federal disaster assistance legislation, however, frustrated postflood mitigation through the emphasis on repairing structures to their predisaster condition. Agency policies gradually began to change and passage of the Robert T. Stafford Disaster Relief and Emergency Assistance Act in November 1988 finally signaled a new approach to postflood recovery. It remains to be seen, however, how effectively disaster assistance funds will be spent for mitigation purposes in the future.

Participants at a 1988 workshop on postdisaster recovery held as part of the 1988 annual conference of the Association of State Floodplain Managers concluded that a "window of opportunity" exists after some floods, particularly major disasters. The infusion of outside expertise and money into a community, combined with damaged or destroyed facilities that must be replaced, represents a large component of this opportunity. In addition, there may be some improvement in local attitudes toward mitigation.

The time during which the "window of opportunity" is open is seen to be quite short. For public facilities, the period might extend for a few months, and mechanisms are in place to identify public facilities that should receive some type of mitigation attention. For private property, the time frame for mitigation was seen as extremely short, from a few days to perhaps as much as three months.

The implementation of mitigation actions on private property is made more difficult by the lack of any routine mechanism (such as exists for public facilities) for identifying needed mitigation actions and delaying reconstruction until a well-considered decision is made. Disaster assistance from government agencies is still primarily intended to speed restoration to preflood conditions, and the speed with which disaster aid is provided has increased, thereby lessening the opportunity for identifying mitigation needs. The window of opportunity might not be available throughout the floodplain area, but might be concentrated in areas of greatest and most frequent damage, such as the 5- or 10-year floodplain. In communities accustomed to structural solutions, however, no postflood opportunity for mitigation may exist (Association of State Floodplain Managers, Workshop #4, 1988).

Many communities may be more inclined to speed recovery to preflood conditions than to undertake mitigation actions. Consequently, state and federal agencies should take the lead in requiring postflood recovery plans and providing assistance in developing and implementing such plans (Fuller, 1989).

SUMMARY AND CONCLUSIONS

A significant increase of information and education-related activities in most areas of floodplain management during the last twenty years is evident in the large number of publications, conferences, training programs, and organizations now involved with floodplain management. Federal agencies have produced much of the information that forms the core of floodplain management knowledge and have been active in providing training in various aspects of floodplain management. States have also released hundreds of documents relating to floodplain management, many based on documents published by federal agencies. As a result, information prepared by the federal agencies receives much wider distribution than it would otherwise. Private sector activities relative to information and education have also increased dramatically.

Flood insurance through the National Flood Insurance Program is now available to residents of more than 18,000 communities. In 1987, just over two million flood insurance policies were in force under the NFIP, with insurance coverage at approximately $114 billion. At the end of 1990, there were 2.39 million policies in force with $201 billion in coverage. Still, only one-quarter to one-third of the approximately nine million buildings in the United States exposed to flooding risks are insured under the NFIP, although participation in the "Write-Your Own" program is expected to increase the number of insurance policies sold and provide coverage to a greater number of structures.

Tax adjustments are commonly used by states and localities following a flood disaster to provide some relief to flood victims. The federal government still provides limited tax deductions for casualties, including floods, but these allowances have been reduced by tax reform measures.

Most communities have developed an emergency preparedness plan, but many have not developed detailed procedures for flood emergencies. Even in the most floodprone communities, specific warning, flood fighting, and other emergency measures for neighborhoods subject to flooding often have not been prepared. Because of the infrequency of flooding, emergency materials such as sand bags are often not available in needed quantities. Many communities rely heavily on the National Guard and other outside assistance.

Traditionally, recovery from floods has meant restoring a community to its preflood condition. Efforts to accomplish postflood mitigation have been undertaken, but progress has been limited.

It is not clear if the present mix of flood insurance, disaster assistance, tax adjustments, and postflood recovery practices are adequately combined to provide an equitable sharing of the capital and operating costs of floodplain occupancy among the beneficiaries. The Unified National Program for Floodplain Management calls for costs to be shared among the beneficiaries and for a minimum of cost-shifting from the individual to the public and government agencies. There has been, however, no clear statement of what portion of the cost of floodplain development should properly be borne by the general public. Some argue that all costs should be borne by those who occupy the floodplain. Others argue that development of the floodplain provides economic benefits, and the general public should therefore assume the burden of any costs associated with floodplain occupancy.

CHAPTER 14:

MANAGING NATURAL AND CULTURAL RESOURCES

If contemporary floodplain managers overlook environmental values, they may be judged deficient, as were their predecessors, for being strongly predisposed toward flood control measures.

A Unified National Program for Floodplain Management, 1976

The second major objective of floodplain management as presented in *A Unified National Program for Floodplain Management* (1986) is to minimize the potential adverse effects of development activities on the natural and cultural resources provided by floodplains. *A Unified National Program for Floodplain Management* describes three broad categories of natural and cultural resources:[1]

1) WATER RESOURCES: The water resources functions provided by floodplains include those related to natural storage and conveyance of flood waters, the maintenance of water quality, and the recharge of ground water.

2) LIVING RESOURCES (HABITAT): Floodplains provide habitat for large and diverse populations of plants as well as fish and wildlife species. Floodplain wetlands, for example, are major sources of food and breeding habitat for both saltwater and freshwater fisheries and for many types of wildlife. Floodplains are especially important and productive sources of energy and nutrients, in large part because they contain the elements of both terrestrial and aquatic ecosystems. The fish and wildlife resources supported directly and indirectly by floodplains represent a renewable resource of great economic importance to the states and to the Nation.

3) CULTURAL RESOURCES: Floodplains provide a wide variety of cultural resources including historical, archaeological, scientific, and recreational sites and opportunities, in addition to highly productive agricultural, aquacultural, and forestry uses. Most of our earliest archaeological and historical sites are found in floodplain areas that can also provide unique opportunities for natural science study and research. In addition, floodplains can provide community open space resources and urban green belts. The recreational opportunities associated with floodplains include opportunities for water-oriented sports, hiking, camping, hunting, fishing, and simple "passive" enjoyment of scenic resources. Floodplains also provide a highly productive resource base for agriculture, aquaculture, and forestry (Federal Emergency Management Agency, 1986).

[1] See Chapter 2 for a more detailed description of the natural and cultural resources of floodplains.

PRESERVATION AND RESTORATION STRATEGIES

Only in recent years have the natural and cultural resources of floodplains been recognized as valuable in their own right. All of these resources are threatened by various human and natural conditions, and particularly by floodplain modification and development. Only a limited type and amount of human uses are compatible with most floodplain resources, and there is general agreement among floodplain management professionals that the natural and cultural resources of floodplains are not being adequately protected.

A Unified National Program for Floodplain Management suggests that the best means of protecting floodplain natural and cultural resources is to avoid floodplain development. Two basic strategies for protection of floodplain natural resources are identified:

1) PRESERVATION OF NATURAL RESOURCES: prevention of alteration of floodplain natural and cultural resources, or maintenance of the floodplain environment as close to its natural state as possible using all practicable means.

2) RESTORATION OF NATURAL RESOURCES: actions to provide re-establishment of a setting or environment in which natural functions can again operate.

Preservation strategies focus on strict control or prohibition of development in sensitive or highly hazardous areas (through establishment of wildlife sanctuaries, for example), while restoration strategies focus on actions to improve the quality or functioning of degraded floodplains (by restoring damaged wetlands, for example). It is not always possible, however, to make a clear distinction between the two strategies. Preservation <u>and</u> restoration of floodplain natural resources are often accomplished, either directly or indirectly, through a wide variety of development controls or by means of regulatory standards designed to protect valuable natural resources or minimize adverse impacts on those resources.

Preservation strategies do not exclude management activities that are compatible with sustaining floodplain functions. Preservation strategies, for example, can include activities to improve habitat conditions and the nonpoint pollution control functions of riparian forests (Lowrance, 1985). Types of regulatory activities and management programs that directly or indirectly contribute to the restoration and preservation of living resources/habitat resources include:

- single or multi-purpose resource management and protection programs that include objectives for habitat and living resources protection, and that apply to floodplains;
- incorporation of provisions for protection of habitat and living resources in zoning, subdivision, and other land-use regulations that apply in whole or in part to floodplains; and
- incorporation of specific provisions related to living resources and habitat protection in floodplain management programs and regulations.

These kinds of programs are directed toward inland and coastal wetlands, estuarine and coastal areas, barrier beaches and sand dunes, rare and endangered species, riverine and coastal fisheries, and wild and scenic rivers. Most of the Nation's wetlands, coastal barriers and marine sanctuaries are located within riverine and coastal floodplains, and restoration and preservation of the living resources and habitat resources of floodplains are often accomplished through multi-objective programs or regulations aimed at protecting inland wetlands, coastal wetlands, or barrier islands.

Preservation and restoration of floodplain water resources has been accomplished through a variety of water supply, watershed management, agricultural erosion control, and water quality maintenance and improvement programs.

Protection of floodplain cultural resources has often been accomplished through open space and recreation planning and urban renewal programs, especially in older cities where early settlement concentrations occurred in the floodplain. Some of these programs include waterfront redevelopment projects, historic and cultural resources protection programs, and a variety of multi-purpose open space programs, including programs that focus on the development of water-oriented recreation, public access, and green belts.

As shown in Table 14-1, there are a number of "tools" that can be used to preserve and protect floodplain natural and cultural resources. The available tools include:

- Floodplain, wetland and coastal barrier regulations
- Development and redevelopment policies
- Information and education
- Tax adjustments
- Administrative measures

As described in *A Unified National Program for Floodplain Management,* "these tools and their application may not be as well documented or understood as those for flood loss reduction, but should be used to support one another and may be integrated with flood loss reduction tools" (Federal Emergency Management Agency, 1986). The National Review Committee writes that "it is clear ... that engineering techniques and institutional means of flood loss reduction are much better understood, and more clearly embodied in various federal programs than are comparable techniques and institutional programs for protection and restoration of natural values" (National Review Committee, 1989.)

Table 14-2 lists a number of ways in which the strategies and tools for natural resource loss reduction may be used to protect floodplain natural and cultural resources.

The following sections of this chapter describe some of the more prominent ways that the strategies and tools have been applied. The same types of tools are also used, as described in chapters 11 and 13, to minimize susceptibility to flood losses and the impacts of those losses. (Descriptions included in chapters 11 and 13 of particular types of programs or actions will not be repeated here, except by reference, or if further description is necessary.)

Table 14-1. Strategies and Tools for Natural Resource Loss Reduction.

STRATEGIES:

1. RESTORATION OF NATURAL RESOURCES
2. PRESERVATION OF NATURAL RESOURCES

TOOLS:

1. FLOODPLAIN, WETLAND, COASTAL BARRIER RESOURCES REGULATIONS
   a) State Regulations
   b) Local Regulations
      1) Zoning
      2) Subdivision Regulations
      3) Building Codes
      4) Housing Codes
      5) Sanitary and Well Codes
      6) Other Regulatory
2. DEVELOPMENT AND REDEVELOPMENT POLICIES
   a) Design and Location of Services/Utilities
   b) Land Rights, Acquisition and Open Space
   c) Redevelopment
   d) Permanent Evacuation
3. INFORMATION AND EDUCATION
4. TAX ADJUSTMENTS
5. ADMINISTRATIVE MEASURES

Source: Federal Interagency Floodplain Management Task Force. A Unified National Program for Floodplain Management. Washington, D.C.: Federal Emergency Management Agency, 1986.

In many cases, actions to reduce flood losses also serve to protect floodplain natural resources. In other instances, flood loss reduction efforts conflict with efforts to protect and restore floodplain natural and cultural resources. There are, however, many instances where flood loss reduction and natural resources protection efforts have been successfully combined.

The Wildlife Management Institute (WMI) has observed that conflicts with flood loss reduction goals can be resolved through integrated management approaches and practices designed by interdisciplinary teams that would include ecologists, biologists, and natural resource managers. In this regard, a new, energetic, and concerted effort should be launched to accomplish the objectives of natural resources loss reduction, and to advance such measures as greenway management efforts that encompass protection for natural resources as well as enhancement of outdoor recreation opportunities. (Jahn, 1989.)

Table 14-2. Examples of Tools for Protecting and Managing Natural Floodplain Resources.

FLOOD STORAGE AND CONVEYANCE:

- Minimize floodplain fills and other actions that require fills, such as construction of dwellings, factories, highways, etc.
- Require that structures and facilities on wetlands provide for adequate flow circulation.
- Use minimum grading requirements and save as much of the site from compaction as possible.
- Relocate nonconforming structures and facilities outside of the floodplain.
- Return site to natural contours.
- Preserve free natural drainage when designing and constructing bridges, roads, fills and large built-up centers.
- Prevent intrusion on and destruction of wetland, beach, and estuarine ecosystems, and restore damaged dunes and vegetation.

WATER QUALITY MAINTENANCE:

- Maintain wetland and floodplain vegetation buffers to reduce sedimentation and delivery of chemical pollutants to the water body.
- Support agricultural practices that minimize nutrient flows into water bodies.
- Control urban runoff, other storm water, and point and nonpoint discharges of pollutants.
- Support methods used for grading, filling, soil removal, and replacement, etc. to minimize erosion and sedimentation during construction.
- Restrict the location of potential pathogenic and toxic sources on the floodplain, such as sanitary land fills and septic tanks, heavy metal wastes, etc.

GROUNDWATER RECHARGE:

- Require the use of pervious surfaces where practicable.
- Design construction projects for runoff detention.
- Dispose of spoils and waste materials so as not to contaminate ground or surface water or significantly change land contours.

LIVING RESOURCES AND HABITAT:

- Identify and protect wildlife habitat and other vital ecologically sensitive areas from disruption.
- Require topsoil protection programs during construction.
- Restrict wetland drainage and channelization.
- Reestablish damaged floodplain ecosystems.
- Minimize tree cutting and other vegetation removal.
- Design floodgates and seawalls to allow natural tidal activity and estuarine flow.

(Continued...)

Source: Federal Interagency Floodplain Management Task Force. A Unified National Program for Floodplain Management. Washington, D.C.: Federal Emergency Management Agency, 1986.

Table 14-2. (Cont.) Examples of Tools for Protecting and Managing Natural Floodplain Resources.

CULTURAL RESOURCES:

- Provide public access to and along the waterfront for recreation, scientific study, educational instruction, etc.
- Locate and preserve from harm historical and cultural resources; consult with appropriate government agencies or private groups.

AGRICULTURAL RESOURCES:

- Minimize soil erosion on cropped areas within floodplains.
- Control use of pesticides, herbicides, and fertilizer.
- Limit the size of fields and promote fence rows, shelter belts, and stripcropping for improved wildlife habitat.
- Strengthen water bank and soil bank type programs in a manner consistent with alternate demands for the use of agricultural land.
- Minimize irrigation return flows and excessive applications of water.
- Eliminate feedlot-type operations.
- Discourage new agricultural production requiring use of drainage.
- Retain agricultural activity on highly productive soils where flood risk is compatible with the value of crops grown.

AQUACULTURAL RESOURCES:

- Construct impoundments in a manner that minimizes alteration in natural drainage and flood flow. Existing natural impoundments such as oxbow lakes and sloughs may be used with proper management.
- Limit the use of exotic species, both plant and animal, to those organisms already common to the area or those known not to compete unfavorably with existing natural populations.
- Discourage mechanized operations causing adverse impacts. Machinery such as dredges, weeders, and large-scale harvesting equipment may lead to environmental problems such as sediment loading in adjacent watercourses.
- Use extreme caution in the disposal of animal waste.

FORESTRY:

- Control the practice of clear-cutting, depending upon the species harvested, topography, and location.
- Complement state law governing other aspects of harvest operations; proximity to watercourses, limits on road-building, equipment intrusions, etc.
- Include fire management in any overall management plans. Selective burning may reduce the probability of major destructive fires.
- Require erosion control plans on all timber allotments, roads, and skidways.

Source: Federal Interagency Floodplain Management Task Force. A Unified National Program for Floodplain Management. Washington, D.C.: Federal Emergency Management Agency, 1986.

REGULATIONS TO PROTECT FLOODPLAIN NATURAL AND CULTURAL RESOURCES

Regulatory measures are among the most widely used and most effective means of protecting the natural and cultural resources of floodplains, and are used by all levels of government. Regulations, however, are limited in their ability to achieve total protection or preservation of floodplain resources and functions, largely because of the possibility for an unconstitutional "taking" of private property if the property owner is denied all potential for economic return on the land. Where complete protection of a resource is required, use of some other tool, such as acquisition, may be necessary (Field, 1981). Important regulations to protect floodplain natural and cultural resources have been established on the federal, state and local levels.

FEDERAL REGULATIONS

Federal regulations protect several types of floodplain natural and cultural resources by limiting the ways, locations and extent to which these resources may be modified. These regulations have been established following the passage of major federal legislation.

The National Environmental Policy Act

The National Environmental Policy Act (NEPA) (P.L. 91-190) enacted in 1970 requires federal agencies to include detailed evaluations of the potential impacts of floodplain development and use on natural floodplain resources as part of the decision-making process. The NEPA requirements have facilitated the protection of floodplain resources by establishing procedures for environmental assessment. NEPA and other legislation and regulations have resulted in a broader view and goal-setting for floodplain management.

The Clean Water Act and the Section 404 Wetlands Regulatory Program

The Clean Water Act, first enacted in 1972 and amended several times since, contains many provisions that protect natural resources and functions. The major regulatory tool at the federal level for managing floodplain natural resources is the Section 404 regulatory program established by the Clean Water Act (P.L. 92-500 and subsequent amendments). Jointly administered by the Corps of Engineers (Corps) and the U.S. Environmental Protection Agency (EPA), the Section 404 program regulates the discharge of dredged or fill material into waters of the United States, including adjacent wetlands. Permit applications are subject to a "public interest review" that includes consideration of floodplain resources and flood hazards (33 CFR 320.4(a)(1)). Permit applications are also subject to a determination of compliance with the EPA's Section 404(b)(1) Guidelines. The Section 404(b)(1) Guidelines provide extensive environmental criteria for judging permit applications, emphasizing the need to prevent avoidable losses of aquatic resources, as well as the need to minimize adverse environmental impacts.

The environmental guidelines provided by the EPA for evaluating "404" permit applications include a series of mitigation measures to minimize the effects (including effects on floodplain natural resources) of permitted discharges. One mitigation option — restoration of alternative degraded sites — "has introduced a number of experiments with the rehabilitation of degraded wetlands, and in a few cases, attempts to create entirely new wetlands" (Platt, 1987).

The EPA has been involved with wetland management efforts (primarily though the Section 404 Regulatory Program) since the agency's inception, and has recently strengthened its management efforts. In 1986 the EPA created a separate Office of Wetlands Protection to increase its wetlands management, protection and research activities and to pursue its Section 404 responsibilities.

In addition to the Section 404 program, other regulatory provisions of the Clean Water Act, such as the provisions governing municipal and industrial waste discharges, are critically important for maintaining water quality or restoring water quality to levels that can support fish and wildlife and associated habitat.

The Endangered Species Act

Plant and animal species may become threatened or endangered as a result of natural events and human activities. Many declining species "are highly specialized and restricted to rather rare and often highly unstable habitats, such as mountain tops, sand dunes, and flood plains, quite often in association with other rare species" (Dowan, 1976).

One of the most significant developments relating to increased understanding and protection of these rare species — including those occupying floodplains — was the establishment of a national program for identifying and protecting rare species of flora and fauna in immediate or foreseeable danger of extinction throughout all or a major part of their geographic range. The Endangered Species Act of 1973 (P.L. 93-205) established a program to designate and protect such species as "endangered" or "threatened." This program is administered by the U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service.

The Act authorizes the Secretary of Interior to identify endangered or threatened species, designate habitats critical to their survival, establish and conduct programs for their recovery, and enter into agreements with states to conserve endangered and threatened species. It further requires other federal agencies to cooperate with the Secretary for enhancement of those species. The U.S. Department of Agriculture (USDA) and Department of Interior (DOI) are authorized to acquire land to conserve designated animals and plants, and federal agencies are directed not to authorize, fund, or carry out actions that may jeopardize the existence of or modify the habitats of endangered or threatened species (Council on Environmental Quality, 1980).

The number of species listed as threatened or endangered has steadily increased over the years, but the actual number of listings is of limited significance. A long list could be viewed as indicating that many species are in danger or that many species receive special protection (Conservation Foundation, 1984).

Many states have developed their own programs for identifying rare and endangered species.

The Coastal Zone Management Act

The Coastal Zone Management Act (CZMA) (P.L. 92-583), provides funding assistance to states (and indirectly to local governments) for a wide range of resource protection activities, including activities that directly or indirectly affect the Nation's coastal floodplains. In addition, the CZMA includes a consistency provision, whereby most federal activities must be consistent with a coastal management program adopted by a state (and by local governments) if the state program has been approved by the federal Office of Ocean and Coastal Resources Management (OCRM). This consistency provision has proven to be a powerful tool for state and local governments to influence federal activities in the coastal zone.

Swampbuster Provisions of the Farm Bills

Under the "Swampbuster" provisions of the Food Security Act of 1985 and the Food, Agriculture, Conservation and Trade Act of 1990, federal agricultural subsidies, farm storage facility loans, crop insurance, and agricultural disaster payments may not be made to farmers who convert wetlands to make possible the growing of commodity crops after November 28, 1990, or plant an agriculture commodity on a wetland converted after December 23, 1985.

Legislation and Regulations to Protect Cultural Resources

The National Historic Preservation Act of 1966 (P.L. 89-665) was passed, in part, because the Congress recognized that federal projects, such as highways, dams, and urban renewal projects, had damaged or destroyed thousands of historic properties during the 1950s and 1960s. The Act required federal agencies to consider the effect of any federal action on historic properties included in a national register of historic sites, buildings, structures, and objects. In 1980 Congress amended the Act, principally Section 110, to require federal agencies to establish historic preservation programs, nominate their historic properties to the National Register of Historic Places,[2] and maximize the use of their historic properties (U.S. General Accounting Office, 1988).

The national historic preservation program has operated as a working partnership between federal, state, and local governments, private citizens, the Advisory Council on Historic Preservation (ACHP), and the National Trust for Historic Preservation (National Trust). In general, the federal government provides guidelines, technical assistance, and grants-in-aid for state and local historic preservation efforts, and monitors its own activities so as not to unnecessarily harm historic properties. State historic preservation officers (SHPOs) coordinate the national program at the state level, assist local governments and the interested public, give them advice on preservation matters, and carry out other aspects of the national program on behalf of the federal government. Preservation work at historic sites takes place primarily at the community level through local governments, nonprofit organizations and institutions, corporations, and interested individuals.

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[2] Properties must be at least 50 years old or have achieved significance of exceptional importance within the past 50 years to be included on the National Register of Historic Places.

The Reservoir Salvage Act of 1960 (P.L. 86-523) required that "before any agency of the United States shall undertake the construction of a dam, or issue a license for the construction of a dam" it must notify the Department of Interior, which was to survey the area. The survey and salvage work is to be performed by the National Park Service (NPS). This law was amended in 1974 to apply to any federal agency whenever it received information that its direct, federally licensed, or federally assisted activities might cause the "irreparable loss or destruction of significant scientific, prehistorical, historical, or archaeological data ..." The 1974 amendments authorized federal agencies to transfer up to one percent of the total authorization for a project to the NPS to pay for the salvage work (Duerksen, 1983).

Most of the recent federal land-use planning laws require that historic and cultural resources should be planned for, identified and preserved. For example, the CZMA authorizes planning and resource protection grants to states. The Federal Land Policy and Management Act of 1976 requires the Bureau of Land Management (BLM) to consider and protect cultural resources on its lands, and the National Forest Management Act of 1976 imposes similar requirements on the U.S. Forest Service. The Wild and Scenic Rivers Act allows rivers to be protected if they have outstanding national significance, including historic features. No rivers have yet been protected solely for historic qualities, but components of the Wild and Scenic Rivers System that have been designated for other qualities may also be managed to protect cultural resources (Duerksen, 1983). Under Section 60.6 of the National Flood Insurance Program (NFIP), communities may issue variances for the application of elevation, floodproofing, or other requirements of the NFIP's minimum floodplain regulations, as these requirements would apply to reconstruction, rehabilitation or restoration of structures listed on the National Register of Historic Places or on a State Inventory of Historic Places. Such variances may be issued if, without the variance, the reconstruction, rehabilitation, or restoration activities would destroy the historic character of the structure and its designation as a historic building (Federal Emergency Management Agency, 1987).

Other Federal Regulatory Programs

Many other federal regulatory programs directly or indirectly protect floodplain natural resources. These include programs established to implement the Safe Drinking Water Act, Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), the Solid Waste Disposal Act (P.L. 94-580), and other federal laws.

STATE AND LOCAL REGULATIONS

Floodplain, wetland, and coastal barrier management and protection at the state and local levels can be accomplished with a variety of regulatory tools that contain provisions for preserving and restoring floodplain resources.

State Regulations

Statewide floodplain, wetland protection, or similar regulations may be applied directly by a state or, as is more often the case, by local communities according to state-established standards.

Wisconsin has adopted a statewide floodplain zoning regulation that requires counties, cities, and villages to adopt floodplain zoning ordinances. The State regulation also establishes minimum use standards for the floodway and flood fringe areas. A shoreland protection law further requires counties to regulate and adopt comprehensive sanitary and subdivision ordinances in all shoreland areas. Shoreland areas are defined as those within 300 feet of streams and 1,000 feet of lakes and flowages (Conservation Foundation, 1980).

As shown in Table 14-3, all coastal states and many inland states regulate wetlands. Several states have enacted coastal wetland regulations focused on wetland protection, including Maine (Alteration of Coastal Wetlands Act) and Maryland (Tidal Wetlands Act). "By 1970, Connecticut and Massachusetts had adopted coastal regulatory programs specifically to protect coastal wetlands. These programs established a permitting system for development activities that would alter the characteristics of coastal wetlands. Both laws became models for numerous other states." "Other coastal regulatory laws, such as Maine's Mandatory Shoreline Zoning and Subdivision Control Act, and Maryland's Chesapeake Bay Critical Areas Protection Act provide wetland protection as one of several program goals" (Cowles, 1986).

The coastal wetland regulatory programs of some states outline minimal criteria (e.g., the proposed projects must be in the public interest or water-dependent) for permit issuance, and all other development is prohibited. Any alteration of the natural topography or habitat, or any damage to flora or fauna requires a permit in the states of Alabama, Georgia, Mississippi, New Jersey, Rhode Island, South Carolina, and Virginia. Under Maryland's Critical Area Program, habitat and water quality enhancement are required for permit issuance. Cumulative impacts are considered in a few states (Florida, Rhode Island) during the permit review process, and mitigation is often a condition for permit issuance in several states (see Cowles, 1986).

Although many states also protect inland wetlands, "inland wetlands nationwide generally receive less protection than coastal wetlands" (Cowles, 1986). Fourteen states administer specific inland wetland protection laws (Connecticut, Florida, Maine, Massachusetts, Missouri, Montana, New Hampshire, New Jersey, New York, Oregon, Pennsylvania, Rhode Island, Vermont, and Wisconsin). The inland wetland programs of some states (e.g., Connecticut, Florida, New York) are delegable to local governments or implemented through district environmental commissions as in Vermont, or by local government as in Massachusetts.

In Michigan, communities have adopted combined floodplain and wild and scenic river regulations pursuant to statutes or river corridor plans to manage these areas for floodplain and other natural values.

Table 14-3. State Regulatory Activities for Protection of Natural Resources.

	WETLAND REGULATIONS	REVIEW FLOODPLAIN PERMITS	SPECIAL PROTECTION PROGRAMS
Alabama	AS		X
Alaska	A		X
Arizona			
Arkansas			
California	S	A	A
Colorado			
Connecticut	AS+,AL+	AS	X
Delaware	S		X
District of Columbia		X	
Florida	S,L		X
Georgia	AS		
Hawaii	S		X
Idaho			
Illinois		X	
Indiana	AS	X	
Iowa		X	
Kansas		X	
Kentucky			X
Louisiana			
Maine	S	X	X
Maryland	AS	X	L
Massachusetts	S,L		
Michigan	S		X
Minnesota	S		
Mississippi	AS		
Missouri			X
Montana			
Nebraska			X
Nevada			
New Hampshire	S		X
New Jersey	S	S	S
New Mexico			
New York	AS,AL	X	
North Carolina	AS		X
North Dakota	AS		
Ohio			X
Oklahoma	AS		
Oregon	L		
Pennsylvania	S	X	
Rhode Island	S		
South Carolina	S		
South Dakota	S		
Tennessee			X
Texas	S		
Utah	S		X
Vermont	S		
Virginia	AS		
Washington	AS		
West Virginia			
Wisconsin	L		
Wyoming			

A = Rules apply only in certain areas, e.g., New York directly regulates tidal wetlands and requires locals to regulate freshwater wetlands.
L = Local regulations must meet state requirements
S = State directly regulates development
\+ = State will directly regulate if locals do not
X = State is involved in this activity.

Source: Association of State Floodplain Managers. "State Floodplain Management Programs. Results of a Survey Conducted by the Association of State Floodplain Managers for L.R. Johnston Associates," 1988.

Local Regulations

Local regulations, including zoning and subdivision regulations, building codes, housing codes, sanitary and well codes, and other regulations, may directly or indirectly address management of floodplain natural resources. Many local zoning and subdivision regulations establish requirements related to protection of floodplain natural resources. These provisions include: specified distances that buildings must be set back from the shore; density limitations in shoreland areas; restrictions or prohibitions on certain kinds of development in highly sensitive areas; and specification of uses compatible with natural resources protection.

A zoning ordinance in Clearwater, Florida includes special regulations for areas of environmental sensitivity, including mangrove and freshwater swamps, barrier islands, coastal beaches, natural drainageways, and aquifer recharge areas.

In addition to floodplain regulations that require permits for activities involving filling, grading or structures, Virginia Beach, Virginia has adopted coastal wetland regulations and sand dune protection regulations that require building setbacks.

Resource-based floodplain regulations in Glastonbury, Connecticut include a density transfer mechanism enabling development rights to be shifted from one location to another.

A variety of other regulatory measures address floodplain natural resources, including regulations pertaining to riparian habitat protection, agricultural use, and zoning.

In California, several communities have adopted ordinances regulating the removal of riparian cover along watercourses to reduce bank erosion, increase ground-water infiltration and provide wildlife habitats.

In Northampton, Massachusetts, 1,500 acres of floodplain along the Connecticut River have been placed in an exclusive agricultural use district.

Glastonbury, Connecticut has zoned approximately 800 acres along the Connecticut River for agricultural use (Kusler, 1982).

Many communities apply several types of regulations in combination with other floodplain management and resource protection measures.

In East Hampton, New York, floodplain regulations are supplemented by a beach grass protection ordinance, tidal and inland wetland regulations, a dune setback regulation, and acquisition of scenic easements to protect wetlands, sand dunes and other areas.

DIFFICULTIES IN USING REGULATORY MEASURES TO PROTECT FLOODPLAIN NATURAL AND CULTURAL RESOURCES

Despite the successful application of regulatory measures on the federal, state and local levels to protect floodplain natural and cultural resources, a number of problems associated with use of these measures have been identified by agencies and groups concerned with floodplain management.

Perhaps the greatest obstacle is that many people object to regulatory restrictions on land use (Jahn, 1989; Sprague, 1989). Largely because of these objections, the "taking issue" is often raised in the course of discussing regulatory measures for natural resource protection (Bureau of Reclamation, 1989; Soil Conservation Service, 1989). Efforts to restrict development for the purpose of protecting natural resources and associated functions are often viewed less favorably than restrictions intended to reduce flood damages to public or private property (Association of State Floodplain Managers, Workshop #6, 1988). Similarly, the courts view efforts to protect natural resources less favorably than efforts to protect property and lives from natural hazards (Kusler, 1989).

Regulations to protect natural resources often conflict with regulations intended to reduce flood losses (DeGroot, 1989). Structural flood control measures, in particular, may result in the loss or degradation of natural floodplain resources if the measures are not properly designed and constructed. On the other hand, well-conceived flood control measures such as dams and reservoirs may sometimes create wildlife habitat and recreational resources in areas where such resources did not previously exist.

Nonstructural measures to reduce losses to life and property may also result in a reduction of floodplain natural resources. Floodplain land-use regulations typically do not include provisions to protect natural resources, and relatively risk-free development in the floodplain may still cause significant loss of natural resources. To avoid this loss, floodplain regulations should include explicit provisions for protection of floodplain resources as well as provisions for reduction of life and property losses (Jahn, 1989). In some instances, this regulatory approach may require regional or watershed-based planning efforts to accomplish both goals while still maintaining development potential (U.S. Environmental Protection Agency, 1989).

DEVELOPMENT AND REDEVELOPMENT POLICIES AND PROGRAMS

Objectives for protecting floodplain natural and cultural resources can be incorporated in a variety of development and redevelopment policies and programs. These policies and programs may be related, for example, to the design and location of utilities and services, open space acquisition, urban renewal, and other actions. Broad policies may be established through legislative or executive action and implemented through more specific, but separate, legislative or program initiatives.

INFLUENCING THE DESIGN AND LOCATION OF SERVICES AND UTILITIES

The design and location of services and utilities can have both direct and indirect impacts on floodplain use and development and therefore on the protection of floodplain resources. Federal, state, and local policies and programs influence the design and location of services and utilities in the Nation's floodplains.

Federal Policies and Programs

Important federal policies and programs influencing the design and location of services and utilities in the Nation's floodplains have been established in the floodplain and wetland Executive Orders, and in accordance with the Wild and Scenic Rivers Act and the Coastal Barrier Resources Act.

- **Executive Order 11988, "Floodplain Management"; and Executive Order 11990, "Wetlands Protection."** At the federal level, these Executive Orders establish policy regarding the placement of federal facilities in floodplains and wetlands. Pursuant to these executive orders, federal projects as well as state and local projects funded or regulated by federal agencies, must be evaluated in terms of the proposed project's impacts on floodplain natural resources.

- **Wild and Scenic Rivers Act of 1968.** The report of the President's Commission on Americans Outdoors, notes that the United States contains almost 3.6 million miles of rivers and streams (President's Commission on Americans Outdoors, 1987). In 1968, the Congress passed the Wild and Scenic Rivers Act (P.L. 90-542) and declared National policy that:

  > *certain selected rivers of the Nation's which, with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values shall be protected for the benefit and enjoyment of present and future generations.*

  Sections 5(d) and 7 of the Wild and Scenic Rivers Act provide specific tools for protecting suitable rivers. Section 5(d) requires that:

  > *In all planning for the use and development of water and related land resources, consideration shall be given by all Federal agencies involved to potential national wild, scenic and recreational river areas, and all river basin and project plan reports submitted to the Congress shall consider and discuss any such potentials.*

In partial fulfillment of the Section 5(d) requirements, the National Park Service has compiled and maintains a Nationwide Rivers Inventory (NRI) of river segments that potentially qualify as national wild, scenic or recreational river areas. As of late 1989, the NRI contained 1,524 river segments totalling 61,700 river miles, and federal land-managing agencies were conducting assessments of rivers on their lands for the purpose of identifying possible additions to the NRI and to the National Wild and Scenic Rivers System.

As of 1990, 9,351 miles in 123 rivers or river segments had been designated as wild or scenic rivers. The U.S. Forest Service manages 3,417 miles of this total. Within the U.S. Department of Interior, the National Park Service manages 2,121 miles, the Bureau of Land Management (BLM) 1,982 miles, and the Fish and Wildlife Service 1,043 miles. The remaining river segments are managed by the states and Indian Nations.

Pursuant to Section 11 of the Wild and Scenic Rivers Act, the NPS has been providing states with technical assistance for conducting statewide river assessments and inventories. These efforts provide a source for potential future, state-administered additions to the NRI and the National Wild and Scenic Rivers System.

Section 7 of the Wild and Scenic River Act prohibits the Federal Energy Regulatory Commission (FERC) from licensing the construction of any dam, water conduit, reservoir, powerhouse, transmission line, or other project works on or directly affecting any component of the National Wild and Scenic Rivers System. Further, no department or agency of the United States shall assist by loan, grant, license or otherwise in the construction of any water resources project that would have a direct and adverse effect on the resource criteria by which the river was designated, as determined by the Secretary of the Interior or, in the case of rivers in National Forests, by the Secretary of Agriculture.

- CONSULTATION DIRECTIVE: Pursuant to the Wild and Scenic Rivers Act and the National Environmental Policy Act, a 1979 Presidential Directive and subsequent Council on Environmental Quality (CEQ) procedures require that each federal agency shall, as part of its normal planning and environmental review processes, take care to avoid or mitigate adverse effects on rivers identified in the Nationwide Rivers Inventory compiled by the NPS. In addition, all agencies are required to consult with the NPS prior to taking actions that would eliminate the possibility of wild, scenic, or recreational status for rivers included in the NRI.

- NATIONAL PARK SERVICE CONSULTATION AND TECHNICAL ASSISTANCE: The NPS river conservation staff offers technical assistance, consultation, cooperation, and coordination with respect to all federal agencies and activities that significantly impact rivers. This assistance is offered in an effort to avoid or mitigate adverse actions on existing and potential Wild and Scenic Rivers, including associated potential trail corridors. Federal agencies and activities of interest include, but are not limited to: FERC licensing/relicensing; federal loans, grants, permits, development projects, and flood insurance; and plans by federal water agencies, the Corps, EPA, DOT, and the USDA.

In cooperation with federal agencies, states and interest groups, NPS river conservation staff jointly review and consult on federal legislation, programs, policies, plans and procedures. A major goal is to cooperatively develop strategies and agreements for redirecting specific federal development subsidies and other activities within sensitive portions of certain river corridors. The intent is to guide growth toward less sensitive areas, thereby optimizing river conservation along with other river corridor objectives, and minimizing the potential for future conflicts. Other major goals include protecting and increasing recreation opportunities along river corridors. The program also encourages and assists other conservation programs such as the Conservation Reserve Program of the USDA, to provide priority for NRI rivers and associated trail corridors.

- **Coastal Barrier Resources Act.** The Coastal Barrier Resources Act (CBRA) (described in Chapter 11) is designed to protect the natural functions of coastal barriers as well as reduce flood losses. By denying federal financial support for most types of development assistance, the CBRA makes it more difficult for private development of these barriers to occur, but does not actually prohibit private development.

State and Local Policies and Programs

Some states have adopted executive orders to control the placement of public facilities on floodplains, while other states directly regulate these public facilities.

In New Jersey, the state Environmental Protection Agency conditioned a sewer grant to the municipality of Cape May in accordance with an agreement that would limit sewer extensions in flood hazard areas (Kusler, 1982).

LAND RIGHTS AND ACQUISITION; OPEN SPACE PROGRAMS AND LEGISLATION

Federal, state and local efforts as well as private sector activities contribute to the acquisition and protection of floodplain land.

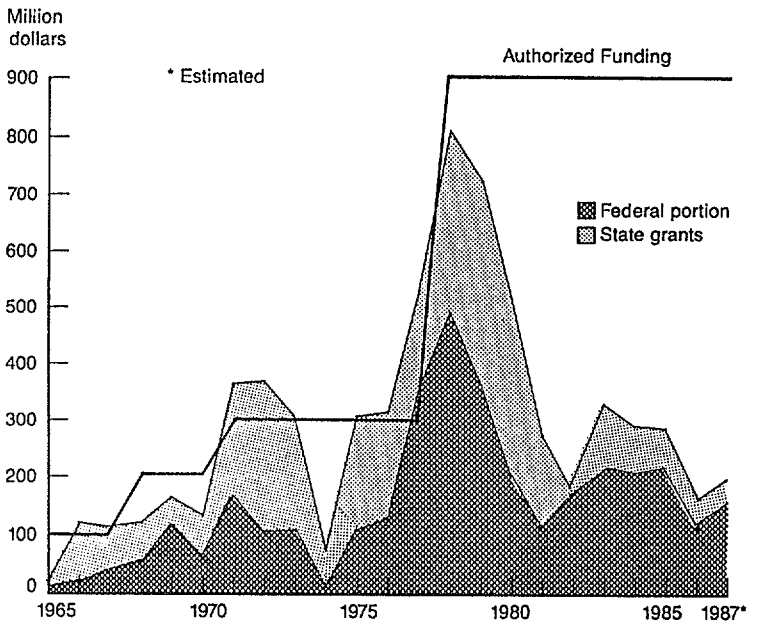
Federal Programs

There are a number of federal laws and programs that provide funding and other assistance that can be used to acquire and protect floodplain land. These include the Land and Water Conservation Fund, the Emergency Wetlands Resources Act, the Water Bank Program, several fish and wildlife restoration programs, and the Endangered Species Act. In addition, the National Estuary Program and federal wetland protection policies contribute to the protection of floodplain natural and cultural values.

- **Land and Water Conservation Fund.** At the federal level, the Land and Water Conservation Fund (LWCF) has been the major source of funding for open space acquisition (40% of the fund is reserved for direct acquisition by federal agencies; 60% is distributed to the states for acquisition and improvement of open space facilities on a cost-sharing basis).

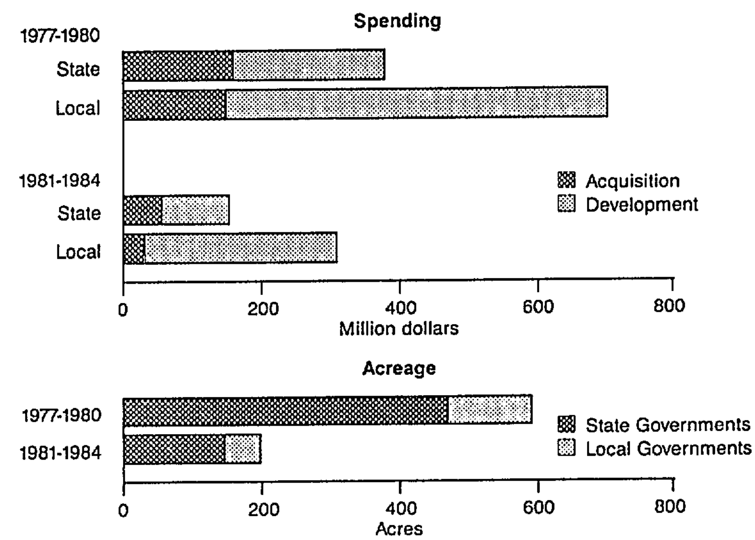
Since 1965 the fund has provided a total of $6.8 billion — $3.6 billion for the purchase of federal parklands and other recreational resources, and $3.2 billion to help states and local governments buy and develop parklands. The fund has provided assistance for almost 32,000 state and local projects. Figure 14-1 shows total LWCF appropriations from establishment in 1965 through 1987. Figure 14-2 shows spending and acreage acquired by state and local governments for the two periods 1977-1980 and 1981-1984. The distribution of LWCF state grants between state and local governments for the period 1977-1980 is shown on Figure 14-3.

The Charles River Project is a well-known example of acquisition efforts by the Corps of Engineers. In the largest federally funded watershed management project in history, the Corps purchased 8,500 acres of wetlands in the Charles River watershed upstream from Boston, Massachusetts. These wetlands provide 50,000 acre-feet of floodwater storage, eliminating the need for a flood control dam or some other form of structural solution.



Source: Myers, Phyllis. State Grants for Parklands 1965-1984: Lessons for a New Land and Water Conservation Fund. The Conservation Foundation, 1987. (Used with permission.)

Figure 14-1. LWCF Appropriations: 1965-1987.



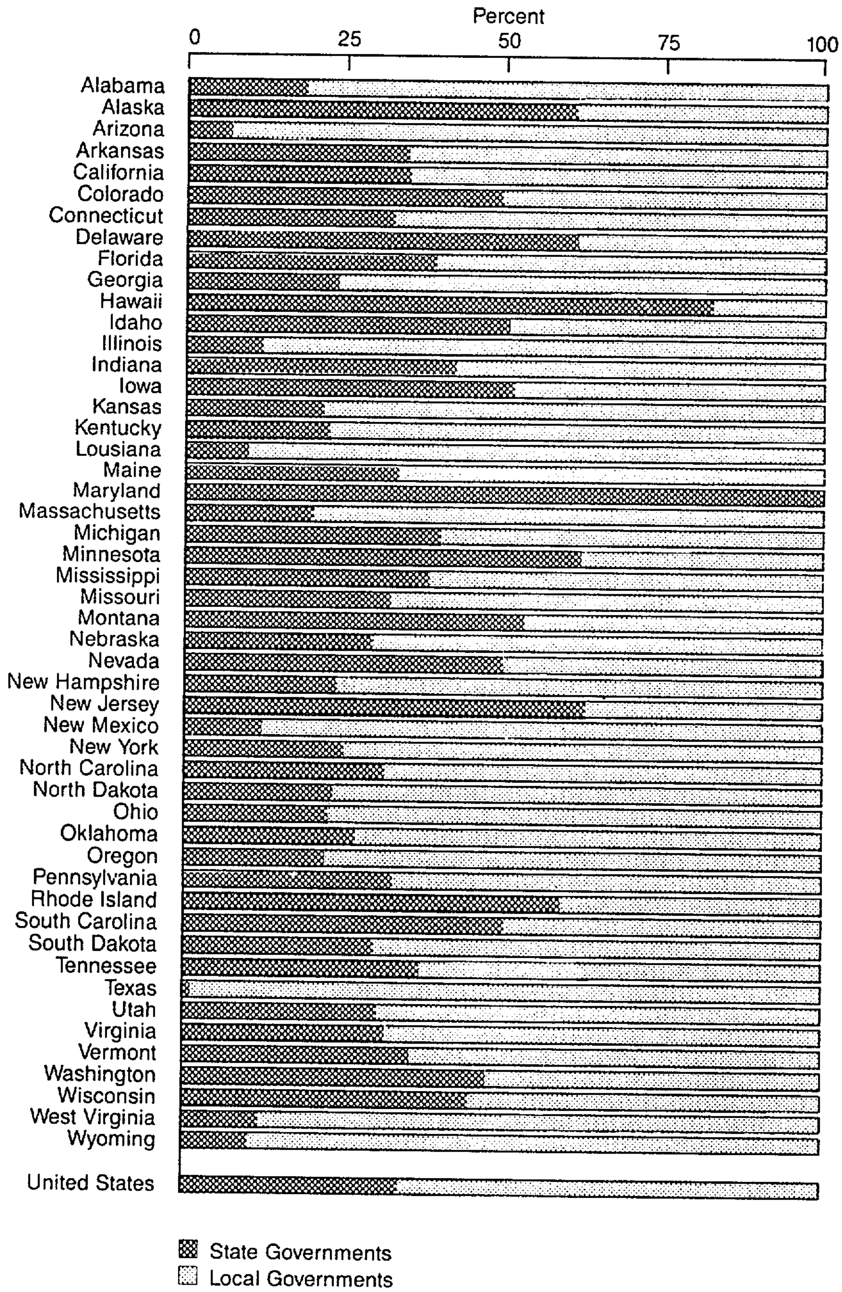
Source: Myers, Phyllis. State Grants for Parklands 1965-1984: Lessons for a New Land and Water Conservation Fund. The Conservation Foundation, 1987. (Used with permission.)

Figure 14-2. LWCF State Grants: Spending and Acreage Acquired by State and Local Governments, 1977-1980 and 1981-1984.

- **Emergency Wetlands Resources Act.** The Emergency Wetlands Resources Act of 1986 requires any State Comprehensive Outdoor Recreation Plan (SCORP) prepared in accordance with the LWCF to address federal and state acquisition of wetlands as an important outdoor recreation resource. Other provisions include establishment of a National Wetlands Priority Conservation Plan for wetland acquisition, completion of wetlands mapping under the National Wetlands Inventory (NWI), and updating the wetland status and trends report (President's Commission on Americans Outdoors, 1987).

- **Water Bank Program.** The Water Bank Program was authorized by the Water Bank Act of 1970 (P.L. 91-559) and is administered by the Agricultural Stabilization and Conservation Service (ASCS) of the U.S. Department of Agriculture. Under this program, wetlands along waterfowl flyways are withheld from farm use under 10-year agreements with landowners. Landowners receive annual payments to help preserve wetlands of importance as breeding and nesting areas for migratory waterfowl. While waterfowl habitat protection is the primary objective of the Water Bank Program, other objectives include flood control, ground-water recharge, and pollution and sediment control. Financial assistance can also be provided for installing habitat and water quality improvement measures (Swader, 1987; Field, 1981).

  The Water Bank Program has been used primarily in the "prairie pothole" region of Minnesota, North Dakota, and South Dakota. From 1979 through 1987, the ASCS had signed 5,044 landowner agreements covering 565,609 acres (Office of Management and Budget, 1988).



Source: Myers, Phyllis. State Grants for Parklands 1965-1984: Lessons for a New Land and Water Conservation Fund. The Conservation Foundation, 1987. (Used with permission.)

Figure 14-3 LWCF State Grants: Division of Funds Between State and Local Governments 1977-1980.

- **Fish and Wildlife Restoration Programs.** For over 50 years the U.S. Fish and Wildlife Service has provided grants to state fish and game departments in support of land acquisition, development, research, and coordination efforts pertaining to fish and wildlife management or restoration. Assistance is provided under two separate programs: 1) Wildlife Restoration (also known as the Pittman-Robertson or P-R Program) authorized under the Federal Aid in Wildlife Restoration Act of 1937; and 2) Sport Fish Restoration (also known as the Dingall-Johnson or D-J Program) under the Federal Aid in Sport Fish Restoration Act of 1950. (The Dingall-Johnson Program was reauthorized and expanded in 1984, and is now referred to as the Wallop-Breaux Program, after the sponsors of the 1984 legislation.) FWS funds will provide 75 percent of total project costs.

  Funds from the P-R and D-J/Wallop-Breaux programs have been used for acquisition of land to develop lakes, provide fishing and fishing access, and develop wildlife and waterfowl management areas. A large portion of land acquired and managed with assistance from these programs is located within floodplains (Field, 1981).

The State of New Jersey used funds from the Federal Aid to Wildlife Fund to acquire additions to the 4,400 acre Cape May Wetlands maintained as a wildlife refuge by the state. Program funds were used to acquire a 315-acre salt marsh adjacent to other state-owned lands previously acquired under the state Green Acres program. The private owner of the property donated 25 percent of the acquired land to the state, which provided the state's required matching funds (Field, 1981).

Under the Fish and Wildlife Coordination Act of 1958, the Corps of Engineers is authorized to give fish and wildlife conservation equal consideration with other project purposes.

When the Wynoochee Dam was constructed in Washington State, a portion of wildlife habitat was lost under the lake and a number of elk and deer were left homeless. To mitigate the loss, 1,034 acres of land were acquired to provide replacement winter rangeland. Within each area, cultivated fields, accounting for 232 acres in all, supply winter forage, while the remaining acres serve as buffer, escape, and cover habitat.

Similarly, the Walla Walla District has begun development of wildlife habitat to compensate for losses of land along the Lower Snake River resulting from the construction of four navigation projects with hydroelectric power facilities. Five thousand acres of Corps-owned land have been allocated for this purpose, of which 1,454 will be intensively managed (Chief of Engineers, 1979).

- **Endangered Species Act.** Section 15(b) of the Endangered Species Act of 1973 (P.L. 93-205) authorized the Fish and Wildlife Service to provide grants to states that enter into cooperative agreements with the FWS to assist in the development of programs for the conservation of endangered and threatened species. Funds may be used for land acquisition, research, habitat surveys, planning, management, and public education. The FWS will normally provide up to 75 percent of eligible project costs (Office of Management and Budget, 1988).

- **National Estuary Program.** The National Estuary Program, authorized by Section 317 of the Water Quality Act of 1987 (P.L. 100-4), provides a planning and implementation program for nationally significant estuaries. This program is for the specific purpose of protecting and improving water quality and enhancing living resources through collaborative efforts called Comprehensive Conservation and Management Plans (CCMP). The program represents an opportunity for comprehensive watershed planning for estuaries.

  Development of CCMPs is carried out by oversight committees (called management conferences) authorized to function for five years by the Water Quality Act. A management conference consists of federal, state, local, and interstate agencies, as well as interested academic and scientific institutions, industries, and citizen groups. Through a consensus-building approach, the management conference establishes program goals and objectives, then identifies and selects the problems to be addressed in the CCMP, and then designs pollution control and resource management strategies to meet each objective.

  Twelve estuaries included in the National Estuary Program have been given priority consideration by Congress:

  Albemarle/Pamlico Sounds, North Carolina
  Buzzards Bay, Massachusetts
  Long Island Sound, New York and Connecticut
  Narragansett Bay, Rhode Island
  Puget Sound, Washington
  San Francisco Bay, California
  Delaware Bay, New Jersey, Pennsylvania and Delaware
  Delaware Inland Bays, Delaware
  Galveston Bay, Texas
  New York/New Jersey Harbor, New York and New Jersey
  Santa Monica Bay, California
  Sarasota Bay, Florida

- **"No Net Loss of Wetlands" Policies.** The desire to reduce the cumulative impacts of wetland losses, supported by advances in identifying the functional values of wetlands, has led many jurisdictions to adopt a "no net loss of wetlands" policy. In some areas, determinations of "no net loss" are based strictly on acreage. In other areas, "no net loss" is addressed in terms of the functional value of wetlands. A combined approach requiring no net loss of wetlands on either an acreage or functional basis is also being pursued by some. Frequently, programs requiring no net loss of wetlands are combined with some type of wetland mitigation banking and wetland restoration program.

  "No net loss" of wetlands policies appear to offer great opportunities for combining flood loss reduction objectives with objectives for the protection and restoration of floodplain natural resources. In 1987, the EPA sponsored a National Wetlands Policy Forum "to address major policy concerns about how the Nation should protect and manage its valuable wetlands resources." In its final report, the Forum made a number of recommendations for protecting and restoring wetlands. Chief among these recommendations was the establishment of the following national wetland protection policy:

> *to achieve no overall net loss of the nation's remaining wetlands base, as defined by acreage and function, and to restore and create wetlands, where feasible, to increase the quality and quantity of the nation's wetlands resource base* (National Wetlands Policy Forum, 1988).

In 1989, President Bush endorsed the concept of no net loss of wetlands, and a new wetlands executive order to replace E.O. 11990 is anticipated. Although not yet embodied in an executive order or federal legislation, the "no net loss" policy has been incorporated into the policies of several agencies responsible for wetland protection.

In February 1990, the EPA and the Corps of Engineers signed a Memorandum of Agreement that clarified policies and procedures to be used in determining the type and level of mitigation necessary to comply with wetland protection provisions (Section 404) of the Clean Water Act (Memorandum of Agreement, 1990). The memorandum lays out a three-step process of: 1) avoidance; 2) minimization of adverse impacts; and 3) compensatory mitigation for unavoidable adverse impacts.

State and Local Programs

State programs that contribute to management and protection of floodplain resources are often open space and recreation programs, and include greenway and river corridor programs as well as programs to protect and restore wetlands. On occasion, these programs are specifically linked to floodplain management. Pennsylvania, for example, has provided flood disaster bond money for acquisition of flood-damaged properties and the conversion of these properties to open space use (Kusler, 1982). In 1987, residents of Maine, New Jersey, Pennsylvania, and Rhode Island voted for bond issues that will generate a total of $300 million for the acquisition, management, and enhancement of public land (Lincoln Institute of Land Policy, 1989). Several states have their own programs to encourage farmers to maintain and manage wetlands for waterfowl habitat.

A review of state acquisition programs conducted as part of a wetland protection study indicated that "... the majority of states have at least one program which acquires wetlands, and some have more than one program. However, many of the programs were not specifically designed to acquire wetlands. Wetlands were frequently acquired incidentally because of their ability to provide habitat for endangered/nongame species and waterfowl, open space, or other values" (Cowles, 1986). Some state acquisition programs, including the New Jersey Green Acre Program and the Florida Save Our Rivers Program, are focused on floodplain areas.

New Jersey's Green Acres Program focuses on acquisition of inland areas, ... and concentrates on watersheds as a basis for stream corridor protection ... Local acquisition is a key element in the program, including 20-year loans at 2% interest, and grants to municipalities with a 25% bonus if environmentally sensitive land such as stream corridors and headwaters are purchased. Municipalities are required to put up open space as collateral ... Fee simple acquisition is preferred for all areas except stream corridors and headwaters, where easements are the preferred alternative" (Cowles, 1986).

In Florida, the Save Our Rivers Program is one of several state acquisition programs that have resulted in the protection of substantial acreage for habitat, water quality and watershed protection, and recreation. The Save Our Rivers Program " ... is a concerted, long-range effort to purchase hundreds of thousands of acres along the state's major river systems in the state's five water management districts, for water management and protection purposes. Substantial acreage has been purchased for restoration of channelized or impounded rivers which feed the Everglades. As part of the Save Our Everglades Program, the state has purchased thousands of acres along the Kissimmee River, to restore it to its original channels, and has initiated a pilot project of marsh habitat renewal. Massive acreage has been purchased in the Green Swamp. The program purchases floodplains in addition to river banks. Management of these lands is within the water management districts" (Cowles, 1986).

As of 1982, an estimated several thousand communities had acquired a portion of their floodplains for park, parkway, wildlife, conservation, agriculture, or other environmental or social uses (Kusler, 1982).

The Mecklenburg County (North Carolina) Greenway Master Plan, developed in 1980, envisioned a network of greenways along the county's creeks that would include 4,000 acres and 60 miles of trails. As of 1986, more than 1,075 greenway acres had been acquired using local park bonds and dedications through the development process. (Over 40% of the acquired acres had been donated by developers and other individuals.)

The 1980 plan for preservation of selected floodplains, which identified priority areas for acquisition along more than 20 creeks, was designed to provide opportunities for passive recreation, habitat protection, and reduction of flood damages that averaged $1.4 million annually. A 20-year land-use plan for the county prepared in 1985 endorsed the greenway program and recommended additional creeks for greenway designation.

Success of the greenway program is attributed to the coordination and cooperation of several government departments and the favorable climate created by actions of elected boards. The Program is administered by the Mecklenburg County Parks and Recreation Department, while most of the dedications arise through the zoning and subdivision review process of the Charlotte-Mecklenburg Planning Commission. Cooperation with other local planning, engineering and regulatory agencies has also been important. To promote the relatively new concept of greenways with the public, a fact sheet on income tax incentives of land donations has been prepared for potential donors, and educational materials for use in local schools were being developed (Brunnemer, 1986).

- **Greenways and River Corridor Programs.** Some floodplain management efforts have been unsuccessful because they were seen to benefit only a select group of individuals at the expense of the entire community. Also, floodplain management controls typically restrict the property rights of individuals who occupy or own land in the floodplain. As a result, such controls may encounter resistance from those who wish to gain the greatest economic return from their property.

To counter these obstacles to effective floodplain management, some jurisdictions have moved to develop programs that combine floodplain management objectives with other community objectives, including those for recreation (open space, hiking/walking, cycling, and other forms of passive recreation, for example) and natural resource protection (water quality and aquifer protection, wetlands protection, and fish and wildlife protection, for example). Because a number of community and public objectives are being met and a broad constituency is being reached, these types of programs are often more likely to gain community support and funding.

These multi-objective programs often take the form of greenway or river corridor projects or, particularly in urban and coastal areas, community redevelopment projects.

The principle federal program providing information, technical assistance, and limited funding for river planning is the State and Local River Conservation Assistance Program administered by the National Park Service with authority provided by Section 11 of the National Wild and Scenic River Act. Projects range from statewide river assessments to greenway plans for a single stream. Statewide river assessments have been undertaken in Maine, Maryland, New York, the Pacific Northwest, South Carolina, and Vermont. Examples of river greenway plans include plans for the Wood-Pawcatuck River in Connecticut and Rhode Island, the Lackawanna River Corridor in Pennsylvania, the Boquet River Corridor in New York, and the Battenkill River in Vermont (National Park Service, 1987).

The City of Scottsdale, Arizona chose a greenbelt over a more typical flood control channel when the Corps of Engineers agreed to provide flood protection for the Indian Bend Wash. This project was much more expensive for the city, since the much greater land acquisition costs for the greenbelt were a local responsibility. However, the city gained a linear park which is in many ways a focal point of the city's recreational activities (Bond, 1988).

The City of Tulsa, Oklahoma provides a prominent example of the effectiveness of multi-objective greenway and river corridor programs for accomplishing floodplain management objectives. Tulsa has experienced seven Presidential disaster declarations in the past 10 years. Despite this history of severe flooding, city officials were unable to gather the public support needed to implement a strong flood loss reduction program. Recently, however, the City introduced a broader river corridor management program that included the development of trails for various recreational uses in addition to floodplain management activities. This concept has met with wide public support and many recreation-based interest groups have joined to support the project. (Flanagan, 1988).

Interest in greenways has been spurred by the release in 1986 of the report of the President's Commission on Americans Outdoors. In its report, the Commission recommended that riversides and stream courses, abandoned railroad rights of way, and other open spaces be used "to link together the rural and urban spaces in the American landscape" (President's Commission on Americans Outdoors, 1987).

- **Wetlands Protection and Restoration Programs, Including Mitigation Banking Programs.** Goals to protect and restore wetlands are continuing to gain importance throughout the country. Most states have now enacted legislation to protect wetlands and additional states are considering such legislation. Many states with existing legislation have found that the incremental loss of small wetland areas still results in an unacceptable cumulative loss of wetlands. In response, these states are acting to tighten existing wetland protection programs. Several states are establishing a variety of mitigation banking programs.

  MITIGATION BANKING: Mitigation banking has been described as "... an innovative alternative for compensating for the unavoidable impacts of development in wetlands where mitigative measures cannot be achieved at or near the site of impact. Banking is not a scientific technique for wetlands restoration or creation, but a management alternative — a way of administering off-site mitigation projects." (Niedzialkowski and Jaksch, 1986)

  At least 10 mitigation "banks" were functioning in the United States in 1986. Although these banks differ in many ways, there are some characteristics that distinguish mitigation banking from other, more traditional approaches to mitigation:

  - Mitigation banking falls within the "compensation" category, and generally applies only to situations in which off-site mitigation is appropriate (e.g., where habitat loss or other adverse impacts are unavoidable and where on-site mitigation is not a viable alternative).

  - Mitigation actions are taken prior to the initiation of development projects, and are generally aggregated at a preselected site, rather than implemented at scattered locations. "Measures intended to create wetlands or enhance wetland values are quantified and, if approved, implemented prior to initiation of the permitted activity requiring mitigation. The permittee or bank sponsor receives credits for the enhancement actions, which are deposited in the "bank." Credits are available for the mitigation of future unavoidable impacts of approved permit activities" (Niedzialkowski and Jaksch, 1986).

  - Mitigation banking generally occurs as part of a broader resource management effort, rather than on a case-by-case basis.

  The following, in varying degrees of formality or complexity, are generally considered as requirements for an effective mitigation bank:

  - Sponsorship by a responsible public agency or private entity with sufficient funds for establishing and implementing a mitigation banking program (including administration, planning, design, and monitoring components).

  - An agreement among the interested parties as to the terms and scope of the mitigation bank. Although informal agreements have been used, a formal document such as a Memorandum of Agreement signed by all involved parties generally defines how the bank will function and specifies the geographic scope of the bank as well as any other conditions agreed to by the signatories.

- An evaluation method to determine how mitigation credits and debits will be calculated (e.g., acre for acre compensation, application of the FWS Habitat Evaluation Procedure (HEP), or use of resource habitat categories based on qualitative measurements).

- A determination of the geographic boundaries or "area of applicability" within which the bank can be used (e.g., a specified hydrologic area, management planning area, or a state-wide area).

- A mitigation plan, or marsh management plan, that establishes the resource management objectives and goals underlying the mitigation banking effort.

- Procedures for monitoring and assessing both short-term and long-term effectiveness of the particular mitigation measures implemented as well as the overall banking effort.

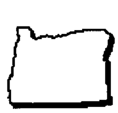
- An explanation of the relationship of the mitigation banking program to ongoing state and federal regulatory programs (e.g., provision for incorporation of applicable mitigation banking actions in an approved permit).

Mitigation banking can alleviate many of the problems associated with other mitigation approaches. It can provide for compensatory actions to be taken prior to development activities, while conventional approaches require that specific mitigation measures be negotiated and implemented simultaneously with project development, or after a project is completed. In addition, mitigation banking can avoid the problem of noncompliance with development permit conditions that specify mitigation actions.

Mitigation banking also provides an opportunity to clarify resource management objectives and achieve the different goals of interested parties, including management and regulatory agencies, as well as developers. The "banking" process can be integrated with comprehensive planning efforts to achieve broader and more regional resource management and economic goals.

Mitigation banking provides a mechanism for mitigating the potential adverse impacts of development activities that may be exempt from permitting requirements (e.g., timbering of bottomland hardwoods), or the impacts of small projects that may not be subject to regulatory control, but that collectively may have significant cumulative impacts on wetlands (e.g., small-scale dredging for temporary road construction to move oil exploration equipment).

Mitigation banking is not, however, a replacement for other mitigation measures and is appropriate only in certain situations. In addition, it requires a great deal of administrative and planning effort, as well as commitments by sometimes numerous participants. A major criticism has been that mitigation banking, if not carefully implemented, can be used to circumvent the permitting process or to substitute for more appropriate mitigation measures.



Mitigation Banking: Columbia River Estuary, Oregon: The Oregon Division of State Lands (DSL), which is responsible for administration of mitigation banks in the State, has defined a mitigation bank as "a large area in which new estuarine habitat is created, or an area previously part of the estuary restored to estuarine function, or an existing estuarine area enhanced by more effective resource management practices" (Oregon DSL, 1987). In 1984, the DSL developed guidelines for mitigation banking, which have since been incorporated in a Mitigation Bank Handbook. The DSL has recommended criteria (size, location, ownership, and mitigation potential) for selection of potential banking sites. Funding sources for mitigation banks may be private or public; in 1987 the Oregon Wetlands Revolving Fund was established by the State Legislature to provide seed money for the establishment of mitigation banks.

Under the Oregon Program, there are three basic steps in setting up a mitigation bank: 1) identification of a proposed site and submittal of an application to the DSL by the sponsor (which may be any legal public or private entity); 2) preparation of a Mitigation Bank Habitat Development Plan (including existing conditions, analysis of mitigation credits, schedule of mitigation activities, and a monitoring program); and 3) signing of a Memorandum of Agreement between the bank sponsor and the DSL.

A pilot mitigation bank program — the Astoria Airport Mitigation Bank — was initiated to offset impacts of estuarine, intertidal, and subtidal water-dependent development. Established under DSL sponsorship, the bank was proposed in response to a Port of Astoria dredging project in the Columbia River which required mitigation. Following two years of planning and habitat assessment, mitigation actions, which involved breaching of an existing flood control dike to expose 33 acres of freshwater wetlands to tidal influence, were completed. In May 1987, a Memorandum of Agreement (MOA) for the Astoria Airport Mitigation Bank was signed by seven state and federal agencies.

According to the MOA, projects eligible for the mitigation bank, developed on land owned by the Port of Astoria and the DSL, must be water-dependent projects within a specified geographic area, approvable under applicable state and federal regulations, and involve unavoidable and necessary impacts where on-site mitigation is unavailable or insufficient. The DSL's habitat relative-value system is used to determine credit withdrawals from the bank, and annual monitoring reports and a five-year evaluation of the project are required by the MOA. Title to the area was to be transferred to the DSL which has responsibility for retaining it in perpetuity for natural resource production purposes (IEP, 1988).

Despite the successful examples of wetland creation and restoration, the Nation still experiences a net loss of wetlands. Over 300,000 acres of wetlands are lost each year; many in floodplains (Meagher, 1988). In addition, not all wetland creation and restoration efforts are successful. There remains considerable controversy over these approaches, particularly where they may be used as a tradeoff for the destruction of other wetlands. In the western United States, lack of available water creates serious obstacles for wetland creation.

Private Sector Activities

The private sector — operating largely through private, nonprofit organizations — has a major role with regard to land acquisition for open space purposes. Much of the land targeted by these organizations is wetland or has some type of water access, and includes much floodplain land. The Nature Conservancy (TNC) and the Audubon Society are two well-known private organizations that operate throughout the United States to acquire and preserve land. The Nature Conservancy reports that as of early 1989 it has been responsible for the protection of 3,643,352 acres in 50 states, Canada, Latin America and the Caribbean (The Nature Conservancy, 1989). TNC owns and manages about 1,000 preserves — the largest privately owned nature preserve system in the world.

In addition to these large national organizations, other organizations operate at the municipal, regional, or state level. In the last 30 years the number of private land trusts in the United States has increased from 50 to over 700 (Lincoln Institute of Land Policy, 1989). These organizations attempt to protect land through acquisition, conservation easements, and other mechanisms.

Several private organizations, most notably Ducks Unlimited, have active programs to preserve wetlands as waterfowl breeding areas.

CONCERN OVER LACK OF INNOVATIVE POLICIES AND PROGRAMS

Policies and programs designed to protect the natural and cultural resources of floodplains have had some success, but many groups and individuals involved with floodplain management have expressed concern over what they see as a lack of innovative policies and programs for the protection of floodplain resources and their associated values.

The Environmental Protection Agency believes that stronger federal support of state and local programs are needed to protect floodplains from development. The EPA also believes that currently innovative flood control efforts such as creation or enhancement of wetlands (thereby improving natural flood retention or reduction features) are not encouraged by federal, state and local agencies due to the potential for failure. Further, federal planning does not promote innovative methods for maintaining floodplain natural and cultural resources. Agencies are reluctant to try innovative planning to protect or maintain these resources, and "current planning guidance and engineering regulations may actually obstruct or reduce the level of federal participation in innovative projects that maintain floodplain natural and beneficial values" (U.S. Environmental Protection Agency, 1989).

The EPA points particularly to the "Principles and Standards for Planning of Water and Related Land Resources" (see Chapter 7) which limit water resources project features to those with quantifiable economic benefits. Since many natural and cultural values of floodplains are difficult to quantify or add only incremental benefits, "the long term costs associated with removing such features or inducing development such that these features are eliminated may not be taken into account."

In addition to removing disincentives for protecting natural and cultural resources, new incentives need to be developed (Tennessee Valley Authority, 1989; Sprague, 1989). Policies such as the "no net loss of wetlands" and "fishable and swimmable waters" are helpful. These policies, however, are not specifically focused on floodplains.

INFORMATION AND EDUCATION

Technical information and public education related to management of floodplain resources are important components of a floodplain management program. Relatively little information is provided that is focused specifically on the natural and beneficial resources of floodplains. A vast amount of information, however, is available regarding the resources and natural functions associated with floodplains.

FEDERAL LEVEL ACTIVITIES

Many federal agencies provide information on natural resources, but the EPA, FWS and OCRM are most active in this regard. Activities include distribution of information on inventories (e.g., the National Wetlands Inventory) and mapping of important natural resources, habitat requirements for species, and measures to preserve and restore natural resources. Federal agencies actively use a wide variety of media to inform and educate professionals, government officials and employees, and the general public. Press releases, newsletters, magazines, journals, and television programs all contribute to creating a more informed population.

STATE AND LOCAL ACTIVITIES

State activities parallel those of the federal government with regard to the types of information and education provided on floodplain natural and cultural resources. Most states have active programs to prepare and distribute literature, films, and other materials, and these programs are typically carried out by state agencies and departments concerned with natural resources, environmental protection, and parks and recreation. Many states offer instruction to local government staff and officials. Activities by local governments tend to be less extensive than state-level activities.

Natural resource inventory and mapping is a major component of many state and local programs. Mapping of wetlands at a larger scale than provided by the National Wetlands Inventory can provide valuable information regarding the most productive and fragile portions of floodplains. "Mapping of coastal wetlands has been completed in Connecticut, Delaware, Maryland, Massachusetts, New Jersey, New York, Pennsylvania, South Carolina and Virginia. In Florida, Mississippi, and New Hampshire mapping is in progress. Minimal mapping is being done in Georgia, Maine, and Rhode Island. Alabama is securing funding now for a major inventory effort to be conducted with several state and federal agencies" (Cowles, 1986). Inventory and mapping of inland wetlands is being carried out by several states, including New York and Rhode Island.

As of 1984, approximately three-fourths of the wetlands in the state of Michigan had been mapped at a scale of 1:24,000. Mapping has been conducted as part of the National Wetlands Inventory with some modifications to the National Wetland Classification System (open water classification is included as is unconsolidated shoreline).

Mapping procedures involve coordinated efforts between the National Wetlands Inventory staff and the Michigan Department of Natural Resources:

- Photographs (initially 1:80,000 scale black & white, replaced with NASA 1:58,000 scale color infrared photos) are supplied by the National Wetlands Inventory staff in St. Petersburg.
- Mylar overlays are placed on the photographs, which are analyzed under the stereoscope to identify and mark wetlands. (Wetlands as small as 3/4 acre can be identified through this process.)
- Quality checks are made by field staff of the Michigan Department of Natural Resources and by the St. Paul regional office of the U.S. Fish and Wildlife Service.
- After draft maps are prepared by a contractor, they are reviewed for accuracy by state and/or federal staff.
- Final corrected maps are prepared for inclusion in the wetlands inventory.

Within the state, maps are used in planning and permitting programs in conjunction with a computerized environmental tracking/warning system (Harrington, 1984).

PRIVATE SECTOR ACTIVITIES

The private sector has an active and major role in providing natural resource-related information and education. Hundreds, if not thousands, of organizations exist across the Nation with objectives to provide information and education for natural resources, including floodplain resources. Many of the larger organizations are listed in Chapter 7. As with federal and state governments, private organizations use newsletters, magazines, television programs, and other media to reach their membership and the general public. Smaller local organizations offer the major advantage of regular meetings, field trips, and other means of providing first-hand information to interested individuals.

LACK OF INFORMATION AND UNDERSTANDING REGARDING THE VALUE OF FLOODPLAIN NATURAL AND BENEFICIAL RESOURCES

Most of the natural and cultural floodplain resources are not associated exclusively with floodplains, but are a specialized and important component of a larger set of resources. While the values of floodplain resources are now well recognized and most natural processes in the floodplain are reasonably well understood, only limited information is available quantifying the value of these natural and cultural floodplain resources. Even wetlands, which are nearly coincident with floodplains and which have been studied extensively, are not well quantified. Estimates of total wetlands in the United States, as well as state-by-state estimates, vary widely depending on when the estimate was made, what definition of wetlands was used, and the survey techniques employed. Improved documentation and quantification (including dollar values) of floodplain natural resources is required to improve public understanding and acceptance of the need for protection (Association of State Floodplain Managers, Workshop #1, 1988).

A major impediment to effective floodplain management as identified by the Wildlife Management Institute is a "lack of understanding of reasons and approaches for effective management, including restoration of natural values and associated outdoor recreational opportunities" (Jahn, 1989). Much of the private sector, particularly developers, appears not to be aware of the natural and cultural resources of floodplains. The emphasis continues to be on deriving the greatest economic return from each site, within the limits permitted by local planning or zoning restrictions. Relatively few developers seem to recognize that the preservation of floodplains and wetlands not only protects important natural resources and functions, but also esthetic values that can enhance property values (U.S. Environmental Protection Agency, 1989).

On the other hand, it has been observed that public officials place a high value on wetlands and floodplains but are not often willing to compensate private property owners for not developing these "valuable" resources. At least one observer has suggested that landowners be compensated for the flood storage value of their undeveloped land (Scheaffer, 1989).

There appears to be widespread agreement that additional information and education is needed regarding: 1) the need to protect floodplain natural resources; and 2) the tools available for maintaining these resources (Bureau of Reclamation, 1989; Association of State Floodplain Managers, Workshop #1, 1988). If greater understanding of their importance can be achieved, increased demand for preserving natural features may follow, and this may have an effect on development action (U.S. Environmental Protection Agency, 1989).

TAX ADJUSTMENTS

Tax adjustments at the federal, state, or local level can play an important role in protecting natural and cultural floodplain resources. Tax adjustments, for example, can influence decisions about floodplain occupancy, can be used to encourage appropriate floodplain use and to discourage inappropriate use, and can also facilitate the acquisition of floodplain land.

FEDERAL TAX ADJUSTMENTS

The Tax Reform Act (TRA) of 1986 (see Chapter 13) eliminated investment tax credits and imposed restrictions on the expenditure of farm conservation investments, which are considered disincentives for draining land for agricultural production (Pavelis, 1987). Provisions of the Internal Revenue Code have an important effect on the conservation and use of floodplain resources.

Tax Exempt Organizations

The Internal Revenue Code provides that organizations meeting certain criteria may achieve tax exempt status. Most conservation-oriented organizations are tax exempt and, as described previously, some of these organizations are actively involved in acquiring wetlands and floodplains. Many other professional and conservation organizations would not be able to carry out their programs of environmental education, technical assistance, and other activities without the advantage of tax exempt status.

Donations to Tax Exempt Organizations

The Internal Revenue Code also provides that individuals and business may receive a deduction for the value of land donated to a government agency or qualified nonprofit organization. Generally the property must be donated in perpetuity and used for some historical or conservation-related purpose. Conservation easements as well as fee simple donations may qualify under provision of the tax code. The TRA of 1986 reduced income tax rates for both individuals and corporations, and raised fears that charitable donations, including land donations, would diminish. Under the TRA, an individual may deduct up to 30 percent of adjusted gross income in a given year. A donation that exceeds this allowable percentage can be carried forward for up to five years. To date there does not seem to be strong evidence that a significant diminishment of deductions will occur. Rapidly accelerating land prices in some parts of the country can have a greater impact on donation decisions than tax rates may have (Evans, 1989).

STATE AND LOCAL TAX ADJUSTMENTS

Positive incentives for the preservation and restoration of floodplain resources may be provided through several kinds of tax adjustments. Tax incentives have often been used to acquire areas for open space uses. "At least 43 states offer broad real estate tax incentive programs for land in agriculture, forestry, and certain other open space uses. Undeveloped floodplains may qualify for reduced taxation pursuant of many to these statutes" (Kusler, 1982).

Two programs in the State of Minnesota — a Water Bank Program and a Wetlands Tax Exemption and Tax Credit Program — compliment the state's regulatory and acquisition programs for preserving wetlands. Unlike the state's traditional programs, both employ relatively new methods. The State Water Bank Program, administered by the Department of Natural Resources (DNR), provides compensation to qualifying landowners who are denied permits for draining designated wetlands for agricultural purposes. Several compensation options are available: 10-year annual payments; purchase by the DNR; permanent easements; conservation restrictions; and leases. As of June 1984, 79 Water Bank projects had been completed, covering close to 3,000 acres of wetlands and adjacent areas.

The Tax Exemption and Credit Program, administered by the Department of Revenue through county auditors' offices, was first enacted in 1979 and amended several times. The tax exemption is automatically determined by the county for the landowner. Eligible wetlands must meet state-established definitions and may include adjacent land that is unsuitable for agricultural purposes due to the presence of the wetlands. Wetlands meeting the state definitions are exempt from property tax.

The Wetlands Tax Credit Program, which is voluntary, is available to landowners who agree not to drain the wetlands in the year the credit is received. Excess credits for wetland property may be applied to the landowners's tax liability for the owner's contiguous property.

The state reimburses the county for revenue lost due to the tax exemption and for the value of the tax credits (Gerbig, 1984).

Funds acquired through a real estate taxation program in Florida are earmarked for acquisition of floodplains and wetlands. The Florida program involves a documentary tax of $.075 per $100.00 on all real estate transactions. This money goes into the Water Management Lands Trust Fund which is divided among five water management districts throughout the state. The money is used for acquisition and management of floodplains and wetlands, including isolated wetlands. Revenue estimates projected over the next 30 years go as high as $1 billion. This program incorporates public participation through hearings prior to each land purchase, and provides for an annual 5-year water management plan update. A substantial amount of public education material is distributed on the program (Cowles, 1986).

ADMINISTRATIVE MEASURES

Many different types of administrative measures can be used to contribute to the preservation and restoration of natural floodplain resources and their associated functions. These measures include:

- restrictions or conditions in contracts, grants, loans, permits, and licenses;
- applications of appropriate encumbrances during land conveyance;
- delegation of responsibility for floodplain activities to a specific office with sufficient authority to play an active leadership role both within and outside the agency;
- systematic review of existing agency programs to identify opportunities for floodplain resource preservation and restoration;
- conservation plans under the Food Security Act;
- federal coastal programs review; and
- coordination within and among agencies to implement unified floodplain management efforts.

There are several prominent examples of administrative measures involving government agencies and private interests for the restoration and preservation of wetlands and floodplains.

Kissimmee River Restoration: Prior to the 1960s, the Kissimmee River in south Florida flowed for 98 miles through a system of lakes and meandering channels from its headwaters to Lake Okeechobee. Between 1961 and 1971, a federal flood control project transformed the Kissimmee River into a 56-mile canal. With this channelization, about 40,000 acres of environmentally sensitive marshland along the original river vanished. The primary aim of better flood control was achieved, but environmental degradation resulted when the area's wetlands were reduced.

Since 1971, efforts have been underway to restore the oxbows and floodplain marshes that had been such an important part of the natural river system. In 1983, the Governor of Florida created the Kissimmee River-Lake Okeechobee-Everglades Coordinating Council and established several objectives for restoration of the river system:

- Avoid further destruction or degradation of these natural systems.

- Reestablish the natural ecological functions of these natural systems in areas where the functions have been damaged.
- Improve the overall management of water, fish and wildlife, and recreation.
- Successfully restore and preserve these unique areas.

As part of the restoration effort, the South Florida Water Management District, in cooperation with other state and federal agencies, agreed to develop, design, construct, operate and maintain a demonstration program to de-channelize the Kissimmee River. In the mid-1980s, a restoration field test was completed with the construction of three weirs, or dams, to divert river flow into the old channel as part of the demonstration project. Water levels are also being monitored, and fluctuation is designed to correspond more closely to natural wet and dry cycles typical of the Everglades. The District hopes to restore as many as 1,300 acres of wetlands into the river system. Information gathered from the demonstration project and other studies is being assessed before additional restoration is undertaken (South Florida Water Management District, 1987).

Wetland Creation: Bottomland Hardwoods in Louisiana: The Soil Conservation Service has completed numerous small watershed projects (P.L. 566 Program) in the state of Louisiana, many of them involving enlargement of channels to remove excess water from agricultural lands. In response to concerns about the impacts of stream channelization, wetlands drainage, and woodlands clearing, the SCS has implemented three projects to create flooded wetlands — called greentree reservoirs — to mitigate the loss of forested wetlands. In the greentree reservoirs, tracts of bottomland hardwoods are impounded and managed to attract waterfowl by seasonal flooding to provide habitat and maintain the integrity of the hardwood stands. Operation and maintenance of the structural components is the responsibility of the local sponsors.

- East Carroll Watershed: A greentree reservoir was created by enclosing a 27-acre tract of bottomland hardwoods with a levee to compensate for the loss of 25 acres of type 1 wetlands. Wells, pumps and water control structures were built to alternately flood and drain the reservoir on a seasonal basis according to a management plan for the area. Total cost for the project was $168,993 ($126,000 SCS; $42,248 local). Conservation easements will protect a larger 455 acres of wetlands as additional mitigation.
- Walnut Roundaway Watershed: An 80-acre greentree reservoir will mitigate the loss of 40 acres of type 6 and 7 wetlands at another site. Water control structures are used to regulate annual flooding, with a total project cost of $136,606 ($102,455 SCS; $34,151 local). The management plan also calls for installation of weirs for maintenance of water levels in 1,574 wetland acres and planting of 421 acres with hardwood seedlings and additional mitigation measures.
- Lake Verret Watershed: Construction of a levee around a 30-acre tract of bottomland hardwood and installation of a well and water control structure for flooding and drainage will provide mitigation for the loss of 29 acres of type 7 wetlands in a channelization project. The area will be flooded seasonally according to a management plan and managed for waterfowl and crawfish production, at a cost of $85,697 ($64,975 SCS; $21,491 local) (Simmering, 1986).

Des Plaines River Wetlands Demonstration Project: A 2.8-mile stretch of the Des Plaines River in northeastern Illinois is the site of a large wetland restoration project. The 450-acre site of the demonstration project is located in Lake County, near Wadsworth, about 35 miles north of Chicago. Project objectives are:

- Demonstrate the benefits of wetland restoration for flood control, water quality improvement, and fish and wildlife habitat enhancement;
- Formulate and evaluate restoration and maintenance techniques;
- Develop and test alternatives to existing environmental investment strategies and water maintenance programs; and
- Create wildlife habitat and recreational opportunities.

The Lake County Forest Preserve District and the Open Lands Project, a conservation organization, formed a not-for-profit joint venture called Wetlands Research, Inc. to undertake the research project. The research design divided the site into two parts. The southern half is designed for passive research, while the northern half is intended for active research. In the passive area, research will be based on observation rather than experimentation. In the active area, eight experimental wetlands are being constructed ranging in size from 4.0 to 11.6 acres. The sites permit earth movement, manipulation of water levels and other research techniques.

Total cost of the project, including land acquisition, is estimated at $10.2 million. Construction started in the spring of 1986, and research is scheduled to continue until 1992. The project is expected to serve as a national model for wetland re-creation and provide important information regarding pollution abatement, flood storage capacity, and other wetland functional values (Wetlands Research, Inc., 1987).

Wetland Restoration: California: As of 1982, at least 33 wetland restoration projects had been completed along California's coast since 1968; the majority in San Francisco Bay and others in Humboldt Bay and San Diego Bay. These projects were of several types, involving experimental plantings on dredge spoils, dike breaching and/or construction of tidal gates and culverts, or major substrate alterations prior to establishment of tidal flows. Some projects were single purpose, while others were designed to fulfill multiple objectives, including wildlife habitat improvement or protection, flood control, public access, mitigation, research, open space, or mosquito control.

The California Coastal Act of 1976 established state policy to maintain and, where feasible, restore the biological productivity and quality of wetlands and estuaries. State guidelines summarize wetland restoration goals and procedures, and some local coastal programs include requirements for wetland restoration plans.

Actual restoration projects have ranged from relatively low cost restoration of diked tidelands to complex, large scale projects.

Two adjacent projects in Freshwater Slough, a tributary of Humboldt Bay, are typical of wetland projects involving restoration of diked tidelands. In the Park Street Restoration Project (approved in 1976), 17 acres of saltmarsh and two acres of riparian habitat were restored by breaching a dike surrounding the areas and constructing a low dike and drainage controls to protect freshwater habitats. Following re-establishment of tidal action, revegetation occurred naturally. Restoration and management of the site is the responsibility of the project sponsor, the Humboldt Bay Harbor, Recreation and Conservation District.

An adjacent restoration site approved in 1984 was designed to restore 23 acres of diked tideland pastures to salt marsh with tidal channels, create nine acres of open pond, and create nine acres of willow swamp through excavation, construction of impoundment structures, and water wells and plantings.

Restoration costs at these sites have been relatively low ($5000 - $7500/acre), requiring a low level of site modification. In addition, the sites were attractive to the sponsors and regulators due to their proximity to adjacent wetlands and access to water.

ADMINISTRATIVE CONCERNS

The successes and failures of recent efforts to manage the natural and cultural resources of the Nation's floodplains point to the need for more coordination among the various disciplines (wetland management, floodplain management, emergency management) that can contribute to protection of floodplain resources. The National Review Committee writes that "Federal agencies have been inconsistent in assimilating the concept of the natural value of floodplains. Their mission statements are accordingly inconsistent. Full implementation of natural value protection is less widespread" (National Review Committee, 1989).

This same view is held by most of the federal agencies with floodplain management responsibilities. A statement from the Federal Emergency Management Agency reflects the concern of other federal agencies that: "... many types of administrative measures can be used to contribute to the preservation and restoration of natural floodplain resources. However, unless there is increased coordination among the various disciplines (wetland managers, floodplain managers, emergency managers) involved in making decisions about such permits, etc., the results will not be satisfactory from a public policy perspective" (Federal Emergency Management Agency, 1989).

SUMMARY AND CONCLUSIONS

Biologically productive and environmentally sensitive areas are geographically coincident with floodplains. However, the National Flood Insurance Program is not statutorily mandated to require communities to preserve the natural resources and associated values of floodplains as a condition for participation in the Program. There are, however, provisions of the Program that can act to preserve and protect the natural resources and functions of floodplains. For example, streambanks and wetlands located in designated floodways are protected, de facto, by a NFIP provision to prohibit any development that would increase flood heights in the floodway. Therefore, limited preservation and restoration of floodplain natural and cultural resources can be accomplished indirectly through flood loss reduction actions. For the most part, however, efforts to manage floodplain natural resources are carried out separately from loss reduction efforts. As described in Chapter 2 of the *Assessment Report*, most of the natural and cultural resources of floodplains are not associated exclusively with floodplains but represent an important component of a larger set of resource values. As a result, with the exception of some riparian and estuarine resource management programs, most programs that serve to protect floodplain resources have not been developed specifically for floodplain application but apply to resources found outside of the floodplain as well.

A wide range of regulatory programs and requirements have been enacted at federal, state and local levels to protect natural resources. These include: programs for wetland protection and control of dredging and filling; environmental impact review requirements; ground-water and aquifer protection programs; erosion control programs; and permit requirements for discharge of pollutants into surface waters.

Numerous programs at all government levels establish policies that encourage, but generally do not require, protection of floodplain natural resources. Land acquisition, the most effective form of protection, has been widely used, particularly by federal and state governments, to purchase wildlife refuges and parks. Other tools such as the purchase of development rights have been used to protect important farmland and unique ecosystems. Private organizations have played a major role in identifying and acquiring important ecosystems.

Information on the importance and functions of floodplain natural resources can receive widespread distribution. Environmental values are widely taught in schools at all levels, and popular television programs reach a wide audience. Additional information is provided by federal and state governments and local environmental organizations.

Federal income and estate tax benefits are available to individuals and organizations who donate land and provide easements to governments and eligible nonprofit organizations. These tax benefits have been a major factor in facilitating private donations of property with valuable wildlife and habitat functions.

Some of the most important types of administrative measures that may be applied to help protect and restore floodplain natural resources address the inventory, classification, and mapping of wetlands, wildlife, aquifers, and other types of natural resources. An important new measure links erosion control actions on agricultural land to federal commodity payments.

These initiatives have done much to increase awareness and protection of floodplain natural resources over the past 25 years. Additional efforts are needed, however, and increased public awareness and education concerning the importance of floodplain natural and cultural resources and the measures that can be used for their protection are also needed. Of perhaps equal importance is the need for improved coordination among government agencies to help ensure that diverse programs work in concert.

PART V:

APPROACHING THE NEXT CENTURY

The concluding chapters of the *Assessment Report* address the extent to which various strategies and tools have helped to achieve the goals of floodplain management. Chapter 15 provides an overview of the effectiveness of the Nation's program for floodplain management and of the activities of that program, and describes some major accomplishments and disappointments. Chapter 16 reviews ways to remedy inadequacies in the program and presents a number of opportunities for improving floodplain management in the coming decades.

CHAPTER 15:

THE EFFECTIVENESS OF FLOODPLAIN MANAGEMENT IN THE UNITED STATES

The real problem ... is that it is very difficult to ... deal in the real world of what has happened and try to evaluate the tradeoffs.

Robertson Mackay, Chairman,
National Flood Insurers Association
Testimony before the U.S. Senate Subcommittee on Housing and Urban Affairs, October 31, 1973

Assessing the effectiveness of floodplain management in the United States is a difficult task. The degree of accomplishment to date is impressive; at the same time a considerable distance remains between the status quo and the ideal that can be envisioned. The economic, environmental, political, and philosophical backdrops against which floodplain management takes place are constantly changing, even though these provide the very standards by which the effectiveness of any national program is necessarily measured. Additional complications are that few clear, measurable goals have been set and there is not enough reliable data about all program activities and their impacts to tell how much progress is being made in a given direction. This chapter describes this fluid and sometimes puzzling scene. It summarizes the key achievements in floodplain management so far, describes some of the difficulties in judging progress, and then reviews the general effectiveness of the management framework and the specific strategies being used to manage the Nation's floodplains.

OVERALL EFFECTIVENESS

There is consensus that floodplain management efforts should be headed in three general directions:

1) FLOODPLAIN MANAGEMENT SHOULD REDUCE THE NUMBER OF FLOOD-RELATED DEATHS IN THE NATION.

2) FLOODPLAIN MANAGEMENT SHOULD RESULT IN AN ACTUAL DECLINE IN THE NATION'S FLOOD LOSSES, INCLUDING PUBLIC AND PRIVATE PROPERTY DAMAGE, INJURIES, AND DISASTER RELIEF.

3) FLOODPLAIN MANAGEMENT SHOULD REDUCE THE LOSS OF THE CULTURAL AND NATURAL RESOURCES OF THE NATION'S FLOODPLAINS.

The first of these goals has been partially achieved. Average annual loss of life from flooding has been somewhat reduced from the level that prevailed early in this century, and has remained relatively constant for many years. Over the last 70 years there has been an average of slightly over 100 flood-related deaths annually; there is no indication that deaths are increasing or decreasing on a per capita basis. Many of the fatalities were onlookers who drove or fell into flood waters.

An actual decline in flood losses (the second goal) has not been achieved. In fact, there was a definite increase in flood damages from 1916 to 1985. Per capita flood damages were almost 2.5 times as great from 1951 to 1985 as they were from 1916 through 1950, after adjusting for inflation. By most measures, the average annual monetary losses attributable to flooding also are increasing. On the other hand, these losses have remained fairly constant over the last two decades when measured against such broad economic indicators as the Gross National Product (GNP) (Wooley, 1986).

The programs designed to protect the natural and cultural resources of floodplains (the third goal) have not yet arrested resource deterioration. Although precise measurements have not been made, there is general agreement among professionals that riparian habitat, wetlands, open space, and other floodplain resources are still being lost in spite of efforts to maintain and restore them.

ACHIEVEMENTS TO DATE

Several significant achievements in floodplain management can be noted, even though all goals have not yet been reached. Among the accomplishments:

- There is widespread public recognition of flood hazards, the value of the cultural and natural resources of floodplains, and the close interrelationship of floodplain hazards and resources.
- Many new programs and initiatives are underway at all levels of government; the legislative base has been expanded and new agencies created.
- Widespread judicial support for floodplain management activities has developed over the last 25 years. Courts have recognized the broad responsibility of public and private landowners to other landowners and to the general public with regard to flood damages of all types; courts are also recognizing a duty and ability on the part of governments to avoid, prevent, or mitigate flood losses. Plaintiffs have won thousands of damage suits against government units for causing or increasing flood damages. Most of these have been based on grounds of nuisance or trespass. The "act of God" defense has diminished as a result of improved flood prediction capability and maps. Improved data on stream flow and better hazard modeling have made proof of causation of flood damages easier. All these changes show a perception throughout society that flood losses can and should be managed in some way, and that government-sponsored control projects are no longer considered the only option.
- In some locales, floodplain development has been prevented or reduced as a result of mapping and the establishment and enforcement of regulations.
- Losses to new development that meets commonly applied flood protection standards have been greatly reduced.

- There has been a shift from federal dominance toward a more equal partnership among federal, state, and local governments.
- There is a greater awareness that no single management strategy is inherently superior to another, and that the most effective mix of strategies and tools varies from one floodplain to another.
- Numerous standards of terminology, procedures, performance, and quality have been developed, providing a uniform means of applying, reviewing, and evaluating the design, construction, and regulation needed for floodplain management, and also providing a limited measure of effectiveness evaluation.

DIFFICULTIES IN EVALUATION

Assessing the effectiveness of floodplain management is hindered by the small number of specified goals by which success can be measured, and by the shortage of data suitable for substantiating evaluations.

The Need for Specified Goals

No single piece of legislation or other authority outlines a comprehensive set of goals and objectives for floodplain management in the United States. Nor is there authority for establishing the relative importance of competing goals, resolving apparently inconsistent goals, or setting out schedules for their achievement or standards for measuring achievement. Goals such as "reduction in flood losses" or "wise use of the floodplain" are very broad for national implementation and not susceptible to precise measurement. This ambiguity in intent and direction has inhibited the development of a truly unified national program for floodplain management.

The Need for a Comprehensive Data Base

There is a considerable amount of information about floodplain management available, but most of this information has not been collected with evaluation in mind and is therefore not precise enough to support judgments about the effectiveness of various floodplain management activities. Without reliable data, it is difficult or impossible to quantify a cause-and-effect relationship between a particular floodplain management activity and any increase or decrease in floodplain losses. This not only inhibits evaluation, but also hinders legislators, regulators, and professionals in their efforts to establish, overhaul, or fine-tune programs and strategies to make them more effective. Although it is sometimes possible to quantify the effectiveness of a particular management effort with regard to a specific flood or flood control project, there are not enough data to make such assessments on a national, or cumulative level.

Many other uncertainties are caused by the incompleteness of the national floodplain management data base. For example, there are conflicting estimates of the total land area of the United States subject to a 1% annual chance flood — estimates range from about 7% to over 14% — and of the annual property damages and loss of life caused by flooding. There are also unresolved questions about how seriously annual wetland loss impairs the natural resources of the Nation's floodplains. In general, both the state- and national-level data that address these subjects are either unreliable or out of date.

The incompleteness of the floodplain management data base has been well documented. A 1983 report to the National Science Foundation stated that "It is evident ... that the nation lacks a comprehensive base of information about many parameters of floods, flood plain use, and the consequences of floods" (Changnon and others, 1983). The recommendation of House Document 465, *A Unified National Program for Managing Flood Losses*, that a national effort be launched to establish a comprehensive data base is the only one of that document's 16 recommendations on which little or no progress has been made. The other 15 have all been implemented.

EFFECTIVENESS OF THE MANAGEMENT FRAMEWORK

The framework for floodplain management today is a coalescence of legislation, programs, policies, and constituencies for flood control, water resources management, disaster assistance, protection of the natural environment, and other objectives. The Unified National Program for Floodplain Management provides the general and working principles for the management of floodplains at each level of government and within the private sector, sets forth strategies and tools for the effort, and stimulates and supports the improvement of floodplain management throughout the country.

THE MANAGEMENT FRAMEWORK'S PROGRESS

Although a truly unified national effort is not yet in place, great strides have been made in that direction. The management framework has matured and expanded significantly since the 1960s. The growing recognition of the need for alternatives to federal investments in structural projects for flood loss reduction has been of particular importance. A major improvement was made in 1979, when the report *A Unified National Program for Floodplain Management*, first published by the U.S. Water Resources Council in 1976, was refined to address protection of floodplain natural resources as well as flood loss reduction. Some of the more important changes in the last 25 years — notably the implementation of the National Flood Insurance Program (NFIP) — have been the result of initiatives to carry out the 16 recommendations made in House Document 465. Other changes, such as the issuance of Executive Order 11988, Floodplain Management, have been the product of action by the Federal Interagency Floodplain Management Task Force. Still others have been achieved through legislative action: the 1988 amendments to the NFIP, for example, provide for flood insurance payments to the owners of structures in imminent danger of collapse due to erosion. Modification of disaster assistance legislation has provided funds for mitigation. These positive changes have been strongly influenced by the efforts of state and local governments and by professional organizations.

SHORTCOMINGS IN THE FRAMEWORK

Experience over the last 25 years has shown that the management framework itself could still be improved. Some of the areas needing attention are: 1) the definition of floodplain management; 2) floodplain management goals; 3) the structure of the management framework; 4) the integration of flood loss reduction efforts with efforts to preserve floodplain natural resources; and 5) coordination among government agencies.

Definition of Floodplain Management

Even though tremendous progress has been made without universal agreement on a definition of floodplain management or what is encompassed by it, efforts probably would be sharpened if there were a concise, generally accepted description. Most of the organizations, agencies, and documents that deal with floodplain management resort to long discussions of an imprecise concept. For example, both *A Unified National Program for Floodplain Management* and the policy statement of the Association of State Floodplain Managers (ASFPM) embrace a broad concept of floodplain management that extends beyond the delineated "100-year" floodplain to include actions that can influence floods and flooding along with actions for the protection and management of natural resources within the floodplain. Elements of insurance, emergency management, disaster relief, and other program areas are included as well. It has been suggested that such views are too broad, and that floodplain management should focus only on reducing losses to lives and property (Sprague, 1989). Perhaps the most widespread (albeit erroneous) view of floodplain management is that it consists simply of regulation of the "100-year" (or perhaps "500-year") floodplain. Floodplain management is also widely viewed as synonymous with the NFIP (Myers, 1989).

An accepted, well-defined concept of floodplain management would improve the implementation of management techniques and simplify evaluations of their effectiveness. It would also make it easier to reconcile conflicting views about accomplishments, effectiveness, and needed changes.

Goals of Floodplain Management

As noted above, the existing management framework contains no clearly specified, measurable goals for floodplain management activities. Goals such as "wise use, conservation, and development," as described in *A Unified National Program for Floodplain Management*, are subject to varied interpretation and cannot be measured on any national scale. Neither have states or municipalities established their own goals or clarified the national concepts. When the goals are restated with discrete targets, it will be easier to direct efforts and to measure the degree of accomplishment.

The Structure of the Management Framework

Because the framework within which floodplains are managed today was not designed at a fell swoop but rather evolved over time, it is not surprising that there are some inconsistencies in the management framework. The most well-conceived component of the framework is the statement of concepts, strategies, and tools contained in *A Unified National Program for Floodplain Management*, yet even that statement could now bear reexamination in light of the past few decades of experience.

For example, strategies for implementing any sort of management program ought to be actions that, if carried out successfully, would result in achievement of the program's goals. The strategies for floodplain management as first identified in the 1976 report *A Unified National Program for Floodplain Management* may now need to be scrutinized with this in mind. After 15 years of efforts to implement the strategies it is still not clear how much progress is being made. This is partly because, due to lack of specific goals, "progress" in the context of floodplain management is amorphous. But it may also be because the strategies as elucidated are not precisely appropriate to the specific achievements desired.

Perhaps there are other strategies that may now be effectively employed; some of the existing strategies, especially as implemented through the current management framework, appear to be working at cross purposes. "Modifying flooding" and "restoring and preserving the natural resources of floodplains," for example, seem to be inherently contradictory. Two of the tools (tax adjustments and postflood recovery) designed for implementing the strategy of "modifying the impacts of flooding" have recently been altered so that they are not directed solely at making flooding impacts easier to bear but also at reducing susceptibility to future flooding (a separate strategy). Finally, some of the strategies seem to have taken on the characteristics of ends in themselves rather than means to reaching goals. Restoring the natural resources of a floodplain, in particular, could well be construed as a goal; it could also be a step along the way to achievement of another, larger purpose; it could conceivably even be both. This confusion is reinforced by the discussion in *A Unified National Program for Floodplain Management* on this point, in which four substrategies are suggested as ways to reach the "goal" of "preserving and restoring natural resources."

More effective management and implementation of a unified program for managing the Nation's floodplains will be possible if these distinctions are made clearer, and if all the components of the framework have better identified relationships to each other. It would be worthwhile in the future to examine the structure of the framework, including the Unified National Program for Floodplain Management, to ensure that the goals, strategies, and tools are all conceptually well-integrated, especially if new components are added or other refinements are made.

Integration of Flood Loss Reduction and Natural Resources Protection

Over the past 30 years, a wide array of new laws and programs has been established aimed at protecting natural resources. The integration of these efforts with flood loss reduction programs has been encouraged through legislation and through Executive Order 11988, Floodplain Management, and Executive Order 11990, Wetlands Protection. Nevertheless, substantial impediments to integrating these two aspects of floodplain management remain. Unless steps are taken now to resolve the inconsistencies, the problem areas may grow as natural resource protection programs mature and gain public support.

Many of the existing programs for flood loss reduction and resource protection are applied within differing geographic areas: most local flood loss reduction programs focus primarily on the "100-year" floodplain, while natural resource protection programs focus on a particular resource (wetlands, for example) which may or may not be located in the floodplain. In addition, the two types of programs are triggered by different events. Disaster relief, for example, occurs after a flood; a Section 404 permit is required when a fill activity is planned; a Wild and Scenic River study begins after Congressional action. These differences make integration of the programs problematic.

Beyond lack of integration, sometimes the programs for the two strategies actually create conflicts, as illustrated in this comment from Denver's Urban Drainage and Flood Control District:

> *The "protection" of wetlands often seems to take precedence over every other aspect of flood plain management. The regulators seem to have no problem in delaying remedial flood control projects in heavily urbanized areas, or driving their costs up dramatically, in order to save very marginal and often trashed out areas. In the meantime, the occupants of the flood plain remain at risk.*
>
> *Similarly, we have had trouble obtaining 404 permits to maintain existing flood control channels. In one instance we were required to build fish ladders, where none had previously existed, before we were granted a permit to repair a series of seriously deteriorated drop structures. At the same time FEMA wants local governments to ... maintain new flood control facilities before FEMA will recognize them on their FIRMs.*
>
> *At the same time that the regulators are busily making it more difficult for local governments to provide flood protection for their citizens, they do very little to promote sound flood plain management practice. On several occasions I have objected to the issuance of a 404 permit on the basis that the activity in question violated principals of flood plain management, such as filling in a floodway, only to be told that kind of activity is of no concern to the authorities administering the program* (DeGroot, 1989).

Coordination Among Government Agencies

There is more coordination and better cooperation among all levels of government now than there was 25 years ago, but improvements could still be made. Each government agency involved with floodplain management has its own legislative mandate and, in general, each has been diligent in carrying out that mandate within the imposed statutory limits. From the standpoint of an overall federal program for floodplain management, however, there are many inconsistencies of purpose and procedure, overlaps, gaps, and conflicts. Fragmented and uncoordinated responsibility and inadequate cooperation among government agencies are frequently cited as obstacles to more effective floodplain management. In the aftermath of Hurricane Hugo in 1989, for example, better intergovernmental coordination and cooperation could have improved the provision of federal disaster assistance to South Carolina. A member of the National Review Committee has described intergovernmental coordination problems extending from the federal government to the local level:

> *At the Federal level, the large number of agencies working in the floodplain management arena operate under a wide variety of laws, regulations and guidelines that make coordination of these many programs difficult, inhibit cooperation, create unneeded competition among agencies, and develop inefficiencies in overall program execution ... Similar problems face floodplain manage-*

ment activities operating at the state and local level ... When action is needed in the floodplain ... myriad agencies rush to respond. However, they must cope with legislated restrictions that limit their ability to cooperate with each other or to develop a comprehensive approach to problem solution. (Galloway, 1989)

The fact that government programs sometimes work at cross purposes is illustrated by the historical case of disaster assistance programs, which were legislatively mandated to provide financial assistance as quickly as possible to the individuals and local governments needing to restore their lives and communities. This usually meant rebuilding public and private buildings to their preflood conditions. In fact, the requirements for receiving assistance from the Federal Highway Administration (FHWA), the Federal Emergency Management Agency (FEMA), and the Small Business Administration (SBA) specifically prohibited rebuilding a flood-damaged structure in a different (even flood-free) location or to a higher design standard. As a result, in the past these programs sometimes actually prevented action that would have reduced future vulnerability to flooding. The Disaster Relief and Emergency Assistance Amendments of 1988 helped to remedy this particular situation by making hazard mitigation activities eligible for federal funding.

THE EFFECTIVENESS OF FLOODPLAIN MANAGEMENT STRATEGIES AND TOOLS

Examining each of the floodplain management strategies and tools separately can help determine exactly where progress is being made. Even though there is not as much information and specific data available about each tool as would be ideal, assessments can be based on observed trends and professional opinions. This process will also help point out places at which the concepts themselves could benefit from redefinition or clarification. There is no doubt that additional accomplishments could be achieved through better or more extensive use of the same strategies and tools. It may also be that some of them have been ineffective or even counterproductive. Perhaps the application of some of the strategies and tools has resulted in unintended side effects. For the purpose of the following discussion, the three strategies to reduce flood losses and the single strategy to restore and preserve the natural resources of floodplains are treated simply as four strategies directed toward floodplain management in general.

Of the four strategies, modifying flooding has traditionally been the most popular because: 1) limited local resources are required for its implementation (most of the costs have been borne by the federal government); 2) individual adjustments or sacrifices are minimal; 3) community growth is not restricted, even in the area "protected" by the structure; and 4) structural measures require only operation and maintenance at the local level because the planning, construction, and implementation are carried out by capable professional staff from the state or federal government. In contrast, many measures to modify susceptibility to flood damages or to modify the impact of flooding are implemented on a structure-by-structure or property-by-property basis and require constant vigilance, personal inconvenience, and financial sacrifice. In the past, these drawbacks resulted in a lack of public support for such measures and, consequently, local governments were often reluctant to impose or enforce them. By the mid-1980s, however, this impediment had been largely overcome and local officials began to focus on how to comply with federal and state requirements and administer community programs. Measures to modify susceptibility to flood damage and disruption and to modify the impacts of flooding are now widely accepted, even though some communities still have difficulty administering them. The strategy of restoring and preserving the natural and cultural resources of floodplains has had little exposure so far, and needs to be better integrated with the other strategies, both conceptually and in practice.

MODIFYING SUSCEPTIBILITY TO FLOOD DAMAGE AND DISRUPTION

A review of the tools used under this strategy shows widespread, fairly successful implementation. Susceptibility to flooding in the United States is constantly being effectively lessened at individual and local levels with these tools. Evidence does indicate, however, that overall vulnerability has either increased or stayed the same, probably because of the large amount of vulnerable development already in place, numerous exceptions to the state and local policies that would reduce that development, and the fact that population growth, movement, and urbanization sometimes take place so quickly or in such unexpected ways that adequate planning and regulation simply cannot be established soon enough to prevent unwise use of floodplain areas. There are still questions about the effectiveness of various types of warning systems, and the extent to which private floodproofing or retrofitting has been used.

This strategy may have the most potential for widespread future use, because its tools can be coordinated well with other strategies and because it works to provide an ongoing, more enduring way of adjusting to the flood hazard — that is, altering human behavior usually before the losses occur.

Floodplain Regulations

Floodplain regulations have been the most widely used tool to reduce susceptibility to flood damages, and they have had the greatest impact. Over 18,000 communities now have adopted at least minimal floodplain regulations as a result of participation in the National Flood Insurance Program, and several states and several hundred communities have adopted more stringent standards. The regulatory aspects of the NFIP are considered to have significantly moderated floodplain development and therefore the damage that would have occurred without the program (U.S. Army Corps of Engineers, 1989). Development after regulations are in effect is less prone to damage than preexisting development. From 1978 to 1988, FEMA recorded an average of 21.7 losses per 1,000 flood insurance policies on structures built before regulation, compared to only 5.7 per 1,000 regulated structures (Thomas, 1990). During Hurricane Hugo, structures built to NFIP standards sustained significantly less damage than structures that did not meet the standards. Mapping of flood hazard areas and enforcement of regulations within the hazard areas have helped to reduce or avoid floodplain development in many locales.

Courts have upheld the constitutionality of floodplain management regulations, despite their impact on property values, because such regulations help protect public health and safety; because they may be part of wider government plans or programs that benefit the public in general (e.g., pollution controls or the NFIP); and because even privately owned water-based lands are subject to public trust and navigation servitudes.

To be effective, regulations must be properly enforced, but this is not always done. Floodplain land-use regulations are enforced at the local level, but many communities find themselves without the resources, public support, or the will to achieve proper enforcement. Experience has shown that some floodprone communities will not pursue enforcement without assistance and/or the threat of sanctions from state and federal agencies. In the past, the lack of sanctions that could be applied by the states or by the federal government hindered effective enforcement. The only sanction initially available to FEMA was suspension of a community from the NFIP — a harsh move that the agency was reluctant to take. In recent years, however, FEMA has begun taking two other steps to increase compliance with adopted regulations: 1) putting the community on probation and imposing a surcharge on policy premiums within that community; and 2) bringing a lawsuit against a community if flood losses are incurred and insurance claims paid as a result of the community's failure to properly enforce the regulations.

Federal requirements for mandatory purchase and maintenance of flood insurance on properties in delineated floodplains must be enforced by federal lending institutions, but a recent postdisaster study conducted by FEMA showed a high rate of failure by the lenders to do so. Because there is no penalty for failure to apply the mandatory purchase requirement, there is no real economic incentive for most lenders to comply.

The widespread use of floodplain land-use regulations has had some drawbacks. The combination of regulations and urban growth has resulted in dense development adjacent to many regulatory boundaries. Such concentration may increase vulnerability to catastrophic losses from large floods (National Review Committee, 1989). Floodplain regulations have had relatively little effect on reducing losses to existing buildings and infrastructure, which make up the greatest potential for flood losses in the country. Between 1978 and 1989, damage to buildings constructed before the adoption of community floodplain regulations accounted for $2.8 billion (93%) of the total $3.0 billion National Flood Insurance Program losses. Both the monetary damages and the number of buildings at risk have increased significantly since the mid-1970s. In addition, the value of the structures in the floodplain tends to increase over time. Finally, to the extent that floodplain regulations allow development in floodplains — even though the potential for damage has been significantly reduced — these regulations can contribute to the loss of natural and cultural resources.

One "built-in" drawback to regulations as currently used is that although the one percent annual chance flood has been clearly established as a national standard, this standard is not always appropriate, and at times may even limit the effectiveness of flood loss reduction measures. Observers have commented:

> *The '100-year flood' standard . . . should be recognized as a necessary, but not always sufficient, geographic parameter for public management* (Platt, 1989).

> *A majority of flood losses that occur in the United States are caused by floods greater than the 100-year flood* (Sheaffer, 1989).

In addition, the National Review Committee (National Review Committee, 1989) has noted that regulatory reliance on a "100-year" flood standard has created a large inventory of structures located just outside the boundaries of the "100-year" floodplain and these structures are vulnerable to floods of greater magnitude.

These opinions, however, are not shared by all floodplain managers and there are not enough hard data to confirm or disprove them. A good argument can certainly be made for applying a higher design standard to such "critical" facilities as hospitals, nursing homes, police stations, fire stations, and waste water treatment plants that must be kept operational during emergencies or where flooding presents a particular threat to human life.

In addition, although FEMA data indicate that damage claims from areas outside the mapped "100-year" floodplain have accounted for about 30% of the NFIP's total claims payments, most of these losses can be attributed to the result of rapid urbanization that exceeds the capacity of managers to remap, regulate, manage stormwater, or accommodate the increased runoff in the drainage area.

Development and Redevelopment Policies

Damages to existing public infrastructure in floodprone areas, including roads, bridges, utilities, and public service buildings, still account for the majority of FEMA's disaster assistance payments. The Federal Highway Administration also provides millions of dollars in disaster assistance for flood-damaged highways and bridges. The process of removal or upgrading (through redevelopment) of the inventory of existing structures in the floodplain is taking longer than anticipated. Data (Donnelly Marketing Information Sources, 1985) and professional opinion indicate that the number and value of properties at risk in the Nation's floodplains is actually increasing.

In a 1983 review, FEMA concluded that Executive Order 11988, Floodplain Management, had been effective in reducing potential flood losses by establishing a federal policy against development and redevelopment in floodplains. Since then, there has been little or no systematic tracking of agency decisions based on the Executive Order guidance to confirm that judgment. In general, E.O. 11988 has been implemented effectively by those agencies that viewed its provisions as supportive of their other programs and missions.

All coastal states have policies on development in coastal flood hazard areas. Several states have issued executive orders or other directives comparable to E.O. 11988, and every state now has a statute or executive order to govern construction of state projects, such as prisons and universities, that are exempt from local regulation. But not all states have strong floodplain development and redevelopment policies. The weaknesses in the state policies are generally exemptions for activities ranging from road and bridge construction to agriculture. The cumulative impact of these exemptions on flood risk and damage to cultural and natural resources can be significant.

Land rights acquisition is not widely used to accomplish flood loss reduction, largely because of the high cost of land, concern about excessive government ownership of land, and challenges of unconstitutional takings. Relocation (permanent evacuation) is used less commonly than other tools except in small isolated sectors of nonconforming uses. In any case, flood damage is rarely the principal motive for redevelopment.

Disaster Preparedness

Disaster preparedness efforts have proven very effective in reducing flood losses, especially loss of life. Every state has an integrated emergency management plan and an emergency management or disaster preparedness agency responsible for preparing for floods. Each Gulf and Atlantic coast state has a hurricane preparedness plan at least underway.

Several organizations and agencies have noted that disaster preparedness plans are not used as much as some other tools and deserve greater attention. In the last 25 years, local disaster response activities have changed very little, but planning has become more systematic and realistic. Even though most local emergency management agencies seem to spend more time producing written plans than actually preparing for a disaster, communities in general are now better prepared for nonwar emergencies (Quarantelli, 1985). Because there has been no systematic study of preparedness plans, their implementation during floods, or detection and warning systems, it is assumed that most of the funding and effort has gone toward flood detection, that preparedness plans are nonexistent or inadequate in many communities, and that where there are both flood detection systems and plans, the plans are unrealistic (Owen, 1986).

Disaster Assistance

The disaster assistance system provided by federal, state, and local governments and the private sector, which takes the form of financial assistance or help to repair, replace, or restore facilities, is largely efficient and adequate to provide necessary relief to individuals and communities. From 1965 through 1989 the President declared 508 major federal disasters related to floods and hurricanes; the total obligation from the Disaster Relief Fund was $5,205,540,000. In a preliminary report the U.S. General Accounting Office noted that in an "average" disaster about 2,000 individuals and families seek federal disaster assistance, and FEMA spends about $10 million (U.S. General Accounting Office, 1990). Other assistance is provided by the Small Business Administration and the Farmers Home Administration (FmHA).

One unfortunate and unanticipated consequence of this effective disaster assistance system has been the tendency of individuals and communities, with very little countervailing guidance from government agencies, to use these funds to return themselves and their property to the hazardous, preflood condition (see later discussion on Postflood Recovery). It is worth ascertaining the degree to which current disaster assistance policies may actually undermine long-range floodplain management efforts to rebuild consistent with the risk (if at all).

Floodproofing

Elevation to or above the base flood level is now routinely incorporated into the design of most new floodplain structures, primarily because it is required under the National Flood Insurance Program, and it has proved effective in reducing losses from 1% or more frequent floods. Further, over the past 20 years new construction methods have been developed to enable structures to better withstand the hydrostatic and hydrodynamic forces of water and the effects of scour and high winds, and many of these methods can be used to meet the special criteria of the NFIP that apply to coastal high hazard areas, for example.

In 1984, the U.S. Army Corps of Engineers (Corps) concluded that use of floodproofing measures (other than elevation) was "widespread" but was unable to estimate the number of floodproofed structures nationwide (Plott, 1987). Likewise, when each of the states was surveyed, few were able to estimate the number of floodproofed structures within their jurisdictions (Association of State Floodplain Managers, 1988a). Although it is not known how many structures have been individually floodproofed, there certainly are millions of existing floodprone homes to which floodproofing techniques could usefully be applied (Federal Emergency Management Agency, 1989). Although floodproofing efforts have long been carried out by individual property owners, most of these private efforts have involved the use of untested systems and procedures, without the usual requisite technical expertise to ensure their effectiveness. Additional methods for retrofitting existing structures to reduce flood vulnerability have been researched and documented in recent years.

Flood Forecasting and Warning Systems and Emergency Plans

Forecasting and warning systems have reduced flood losses, particularly loss of life. In one documented example, an annual damage reduction of $750,000 was estimated for the Connecticut River Basin as the result of a flood warning system that cost about $250,000 annually (Day, 1976). A later study estimated a 20:1 ratio of benefits over costs for a statewide warning system for Connecticut (Committee on Automated Flood Warning, 1988). Many automated warning systems have been installed primarily to save lives, and it is impossible to establish a useful benefit/cost ratio for such systems (Association of State Floodplain Managers, Workshop #7, 1988b). The performance of automated flash flood warning systems that have been installed in communities in Arizona, California, Colorado, Connecticut, Maryland, Nevada, New York, Pennsylvania, and Texas, has been uneven; many have not been tested under actual flooding situations to determine if they will indeed provide the anticipated level of warning. In a recent study of 18 warning systems, nine had not yet had experience with flooding. Of the others, seven worked acceptably, and two had problems (Association of State Floodplain Managers, Workshop #7, 1988b). There have been few formal evaluations of flood warning systems in the literature, and no "before-and-after" studies of effectiveness.

The effectiveness of flood emergency measures varies widely according to the locality, the type of flooding and measures available, and the state of preparedness of the populace. Most communities that experience only rare flooding do not have current, workable emergency plans, but this deficiency often is offset by the skill of the local police, fire, and public works departments.

MODIFYING FLOODING

National efforts to modify flooding have probably been more successful than those of any other strategy. The concept of controlling floods is older than the other strategies, and over the course of five or six decades, countless flooding situations have been altered by means of structural measures. Between 1936 and 1975 the federal government spent more than $13 billion for dams and other flood control structures (U.S. Water Resources Council, 1977). In return for this investment, flood control projects have saved billions of dollars in property damage and protected hundreds of thousands of people from anxiety, injury, and for some, death.

There is an increasing recognition that the strategy of modifying flooding can sometimes be counter-productive in two ways. First, it has been suggested that the creation of structural protective works encourages development in the "protected" area, resulting in increased vulnerability, perhaps not to the design flood, but to larger floods or to unforeseen catastrophic events like structural failure. Second, unless it is planned and implemented very carefully, this strategy is incompatible with preserving and restoring the natural resources of floodplains. Structural measures can have adverse impacts on wildlife habitat, scenic resources, and water quality that undermine the effectiveness of comprehensive floodplain management.

Partly as a result of these concerns and partly because the most-needed projects had already been built, there was a considerable shift away from reliance on structural solutions beginning in the early 1960s. The planning and installation of measures to modify floods, however, have not been abandoned. Flood control projects are still needed to complement the application of other floodplain management strategies, particularly to protect existing structures. From time to time, Congress has authorized flood control projects in water resources development acts, and agencies such as the Corps and U.S. Soil Conservation Service (SCS) have ongoing authority to plan and carry out local flood protection measures.

There is not enough information to determine the extent to which each of the tools to implement this strategy are being used, although there seems to be a trend toward the abandonment of certain land treatment measures (terracing, for example) in the wake of the use of large, mechanized farm equipment. This is particularly disturbing because a large proportion of flood losses occur to agricultural lands.

Dams and Reservoirs

Between 1960 and 1985, Corps projects prevented an estimated $245 billion (1985 dollars) in potential damages. Since its inception, the Tennessee Valley Authority (TVA) dam and reservoir system has prevented flood damages that would have amounted to nearly $3.03 billion. No estimate is available of the number of people being afforded some degree of protection by dams.

Dikes, Levees and Floodwalls

About 1,000 communities (5.5% of floodprone communities) have levees and floodwalls that provide protection from "100-year" floods; the cumulative length of these structures is about 9,000 miles and they protect about 5,000 square miles of land. An estimated 25,000 miles of levees and floodwalls have been built nationwide, but most of these structures are designed only to protect agricultural property from small floods. Levee or floodwall overtopping or failure is involved in about one-third of all flood disasters.

Channel Alterations

As of 1976, the SCS had helped construct or modify nearly 17,000 miles of channels. Such channels are effective at protecting agricultural lands from frequent, small floods. Other agencies, such as the Corps, also participate in channel construction for flood control.

High Flow Diversions

Diversions have very limited but specific application for reducing flood damages. There is insufficient information about the use of this tool to judge its effectiveness at this time.

Land Treatment Measures

As of 1977, terraces were in use on an estimated 31.3 million acres of land, and an average of 600,000 additional acres were being protected annually. Many of these terraces, however, are now being torn out. A significant proportion of all U.S. cropland is in some form of conservation tillage. Pursuant to the 1985 Farm Bill, all farms with highly erosive lands must now have conservation plans.

On-site Detention Measures

There is insufficient information about the use of this tool to judge its full effectiveness at this time. It is being used more frequently in certain areas of the country.

Shoreline Protection Measures

One tool not identified in *A Unified National Program for Floodplain Management* but which has come to be widely used includes shoreline protection measures. The effectiveness of these measures varies widely. Sand fills and other beach nourishment techniques protect upland development without interfering with the littoral transport of sediment. Structures like breakwaters, seawalls, bulkheads, and revetments can prove ineffective at providing long-term flood and erosion protection if they are not properly engineered, because they then tend to fail at their flanks, allowing continued erosion of the adjacent shoreline. Structures like jetties and groins can provide longer-term protection, but they may interfere with the natural movement of sand and degrade or destroy natural and cultural resources along the shore.

MODIFYING THE IMPACT OF FLOODING ON INDIVIDUALS AND THE COMMUNITY

The impacts of flooding on individuals and communities have definitely been reduced over the last 20 years, largely through increased awareness of flood hazards as a result of the provision of information and education, and because of the availability of flood insurance. After many years of counterproductive effects, two of the tools for implementing this strategy have recently undergone basic revisions that may make them more effective at reducing future losses: tax adjustments for flood losses have been reduced, and postflood recovery measures to minimize future losses have been determined to be an appropriate use of disaster assistance funds.

Information and Education

Public perception, awareness, and response to flood hazards is significantly greater today than it was in the mid-1960s, partly as a result of increased information and education for floodplain management. The extensive use of this tool is evident in the large number of publications now in existence, conferences and training programs held, and organizations now involved in floodplain management. Federal agencies have produced much of the information that forms the core of floodplain management programs and have been active in providing training. The Federal Insurance Administration (FIA) now spends about $4 million annually to print and distribute about seven million maps to states, communities, lenders and agents, banks, consultants, and others. The states have prepared hundreds of documents on various aspects of floodplain management. Private sector activities with regard to education and information dissemination have also increased dramatically. There has been a tremendous increase in the number of professional and nonprofit organizations with some involvement in floodplain management.

Although substantial progress has been made in increasing institutional awareness and response to flood risk and vulnerability, individual perception and awareness generally falls short of the level that many professionals and public officials think is needed. Some believe that this condition is the greatest impediment facing floodplain management today (Soil Conservation Service, 1991). Only a portion of the affected public usually responds appropriately to flood warnings or advice about flood risk, and sometimes this lack of response has disastrous results.

The American Planning Association (Smith, 1989) and Burby and French (Burby and French, 1985) have found that floodplain management is simply not a priority for local governments and that floodplain control is not perceived as a serious problem by the thousands of suburbs, small towns, and rural communities with designated floodplains. This lack of perception can be attributed in part to inadequate information and lack of awareness on the part of floodplain residents and local officials. There is not the same level of public and local political support for floodplain management as there is for programs to protect other sensitive environmental areas or resources (like wetlands). Lack of funding and personnel also limit the effectiveness of local floodplain management programs and reduce the priority attached to them. The expectation of outside assistance for postflood recovery reinforces local attitudes that higher levels of government will provide any needed remedies.

It is difficult to keep local elected and appointed officials adequately informed due to their high turnover rate (Federal Emergency Management Agency, 1989), especially volunteer boards and commissions that play a major role in local government in some sections of the country. The American Planning Association believes that responsibility for educating and informing local officials rests with the federal government and the states, and is concerned that:

> *federal and state floodplain managers have not done an adequate job of informing the public and local elected leaders of the benefits of floodplain management ... [or] ... of educating local planning boards, city councils, real estate salesmen, bankers, and developers of the need to prevent excessive development of floodplain areas* (Smith, 1989).

At all levels of government, the limited number of personnel with specific training in the interdisciplinary field of floodplain management is a significant impediment.

Some local government officials believe that strict local land-use regulations designed to protect against flood hazards may be challenged as unconstitutional takings of private property without compensation. Although this concern is rarely well-founded, it still can hinder both local adoption and enforcement of regulations more stringent than the federal standards.

Flood Insurance

As of 1990, 82% of the Nation's nearly 22,000 floodprone communities had joined the National Flood Insurance Program. In 1990, 2.39 million flood insurance policies were in force, providing insurance coverage in excess of $200 billion. From 1978 to 1989, over 384,000 claims had been paid for a value of about $3.2 billion. For many thousands of property owners and renters, the availability of flood insurance has greatly eased the financial trauma created by damaging floods. NFIP experience is beginning to yield evidence that the flood loss reduction standards are preventing flood damages and that the insurance mechanism is shifting a significant amount of flood damage costs from disaster assistance programs to floodplain occupants.

Since the NFIP was authorized in 1968, the Federal Insurance Administration has made significant strides toward increasing the number of structures insured on an actuarial basis and achieving a financially self-supporting NFIP. Since 1985, premium income has been sufficient to cover all expenses and claims, including $365 million for Hurricane Hugo, without utilizing the program's federal borrowing authority. The Write Your Own (WYO) program is expected to increase the number of policies sold and provide coverage to even more structures.

Because only a small percentage of floodprone structures are insured, and many structures are still insured at subsidized rates, the premium base is not large enough to permit the NFIP to operate on a fully actuarial basis. Those structures covered by insurance tend to be the ones at most risk. The number of policies has remained relatively constant for several years, but new structures continue to occupy the floodplain and there is no evidence that the existing inventory of structures is significantly declining. Consequently, the number of policies should be steadily increasing.

For years there have been claims that the NFIP has contributed to an increase in floodplain development. No studies have specifically addressed this issue. Neither the data collected and maintained by the FIA nor other readily available data provide a conclusive answer. There is no doubt that development in floodplains has continued and perhaps even accelerated (especially in coastal areas) but there is no evidence that this development has been induced by the availability of flood insurance. It may be a result of increasing population, more water-related leisure activities, or other factors. Because infrastructure is a prerequisite to development, flood insurance at most probably only acts as a contributing factor.

Tax Adjustments

It is not known yet whether the federal Tax Reform Act of 1986 has reduced the tax code's historic incentive to develop property without regard to flood risk. There are scattered state and local tax adjustment programs whose impact also is unknown.

Flood Emergency Measures

All states and most localities have some sort of emergency management office or agency responsible for preparing for floods. There is little specific information about how much or how effectively certain emergency measures are used, except in the case of hurricane preparedness. Because of the seriousness of this threat, all coastal communities have some form of emergency preparedness and most have effective evacuation plans as a result of the cooperative hurricane evacuation study effort by federal, state, and local agencies.

Postflood Recovery

Postflood recovery efforts, aided by many types of disaster assistance, have been largely effective at restoring flood-damaged communities and individual properties to their preflood conditions. It has recently been recognized, through changes in federal legislation and policy, that those preflood conditions were hazardous conditions that should not have been recreated. In late 1988 the passage of the Disaster Relief and Emergency Assistance Act signaled a new approach to postflood recovery, making hazard mitigation activities eligible for federal funding. This should make it easier for individuals and localities to take mitigation actions. It remains to be seen whether the Act will actually motivate and enable state and local officials to use disaster assistance funds for postflood mitigation.

RESTORING AND PRESERVING THE NATURAL RESOURCES OF FLOODPLAINS

As the latest addition to the array of floodplain management strategies and the one least well-integrated with the others, it is not surprising that the strategy of restoring and preserving the natural resources of floodplains has met with minimal success. Floodplain land is being preserved in a limited way through regulatory controls and through acquisition; public understanding and support for preservation and restoration of natural resources is growing; and mapping of the Nation's wetlands is more than half finished. These accomplishments, however, have been the result largely of programs, policies, and efforts outside the floodplain management arena. There is little debate that the natural and cultural resources of floodplains are still being lost.

Regulations

A wide range of regulatory programs and requirements has been enacted at federal, state, and local levels to protect natural resources; these include programs for wetlands protection and control of dredging and filling, environmental impact review requirements, ground-water and aquifer protection programs, erosion control programs, and permit requirements for discharge of pollutants into surface waters. In addition, as of 1986, 7,365 miles on 72 rivers had been designated as wild or scenic, and therefore protected under federal law. Nevertheless, proposed river alterations by dam construction, channel modification, and other flood control projects greatly outnumber the stream segments currently protected under federal or state statutes.

Many people object to using regulations to restrict land use, and especially for the purpose of protecting natural resources (Jahn, 1989; Sprague, 1989; Bureau of Reclamation, 1989; Soil Conservation Service, 1989). There has been less judicial support for the constitutionality of land-use regulations that protect natural resources than for regulations that protect life and property (Kusler, 1989).

In general, regulations to protect natural resources are not well integrated with those to reduce flood losses, resulting in conflicts when implementation and enforcement are at stake. There have been more and more recent instances, however, in which natural resource protection regulations have been integrated with flood loss reduction measures to yield flood control projects that are environmentally sensitive.

Development and Redevelopment Policies

Numerous programs at all levels of government establish policies that encourage, but generally do not require, the protection of the natural and cultural resources of floodplains. State policies governing development and redevelopment on floodplains generally contain exemptions for certain activities, such as road and bridge construction or agriculture, and the cumulative impact of these exemptions significantly damage natural resources.

Land acquisition — the most effective form of protection — has been widely used, particularly by the federal government and the states, to establish wildlife refuges and parks. A considerable amount of floodplain acreage, particularly wetlands, has been preserved through government and private sector efforts to acquire or otherwise protect important natural areas. Other tools, such as the purchase of development rights, have been used to protect important farm lands and unique ecosystems. Private organizations have played a major role in identifying and acquiring important natural areas. As of 1989, The Nature Conservancy alone had been responsible for the protection of 3,643,352 acres in the United States, Canada, Latin America, and the Caribbean islands. Several thousand communities have acquired a portion of their floodplains for parks, wildlife areas, conservation, agriculture, or other environmental or social uses.

Information and Education

Only in recent years have the natural and cultural resources of floodplains been recognized as important in their own right. Hundreds or thousands of private organizations now exist across the country to inform and educate the public concerning natural resources, including those found on floodplains. During the last 25 years or so, the combined effects of research, legislation, and education have heightened public environmental awareness and support for all types of protection programs. There is also greater recognition that natural environmental resources and flood risk are closely related. Harris polls taken in 1981, 1984, and 1986 found that support for protecting the environment regardless of cost was supported by 45%, 58%, and 66% of the population, respectively. Likewise, 83% of those polled in 1982 believed that it was very important to preserve the Nation's wetlands, and in 1985, 85% of those polled favored strict enforcement of the Clean Water Act and its wetlands protection requirements.

Although substantial progress has been made in increasing institutional awareness and response, individual perception and awareness generally falls far short of the level that many professionals and public officials believe is needed. Even where individual awareness is high, it does not necessarily translate into action that will preserve or restore natural resources, particularly if the appropriate actions would affect the individual's own property. Resistance to restrictions on private property rights is generally high. Also, the loss of flood storage potential, wildlife habitat, and other natural resources is often viewed as inconsequential if the losses are relatively small and the area affected is not large. It is hard for community officials to address the cumulative impacts of a series of individually small actions that, collectively and over time, may have significant effects on natural resources.

Local land-use regulations designed to maintain natural resources in floodplains may realistically be challenged as unconstitutional takings of private property without compensation, depending on the issues and objectives involved in each particular situation. Concern about this sort of challenge may dampen local willingness to adopt and enforce regulations more stringent than the federal standards.

Tax Adjustments

Federal income and estate tax benefits have facilitated private donations of property with valuable wildlife and habitat functions. These tax benefits are available to individuals and organizations who donate land and provide easements to governments and eligible nonprofit organizations. At least 43 states offer real estate tax incentives for land in agriculture, forestry, and certain other open space uses, and undeveloped floodplains qualify under some of the statutes.

Administrative Measures

There is currently not enough information about the use of this tool to judge its effectiveness.

SUMMARY AND CONCLUSIONS

Since the Bureau of the Budget Task Force on Federal Flood Control Policy issued its seminal report —*A Unified National Program to Reduce Flood Losses* — more than 25 years ago, floodplain management has matured from a focus on reducing flood losses by using structures to a broader approach that incorporates structural and nonstructural measures for flood loss reduction and takes into consideration the protection of the natural and cultural resources of floodplains. Legislation, programs, and policies geared toward wisely managing the Nation's floodplains have blossomed at all levels of government throughout the country; the private sector and the academic world have participated energetically; fruitful alliances have been formed among seemingly unlikely partners; public awareness and judicial support have increased steadily. The examples of flood damages averted, lives saved, and resources preserved are plentiful. It is evident that substantial progress has been made, and that diligent work is underway to overcome past shortcomings and achieve even greater progress. Even in the light of this undeniable progress, however, there is yet no feasible way to make quantified judgments about the effectiveness of floodplain management activities in relationship to overall goals or program costs.

Some trends in the use of the various tools and strategies over the last several decades can be noted, along with general observations of their effectiveness. The strategy of modifying susceptibility to flooding has been pursued diligently by means of all its tools, although regulations are the most visible. A number of effective ways to prevent damages from floods have been developed, from construction techniques to innovative zoning schemes, and these have been translated into regulations and development policies throughout the country. This strategy will likely be more extensively employed in the future because of its capability to actually prevent many damages without undermining other program objectives or activities.

Almost all the available tools for modifying flooding (the second strategy) have been used to thoroughly implement the strategy, and there are even dollar estimates of its effectiveness in saving lives and reducing damages. Over the past decade the structural measures associated with this strategy have been implemented less frequently, because of their cost and potential negative impacts.

With regard to the third strategy, the impacts of flooding on individuals and communities have been dramatically modified by the provision of flood insurance (which is coordinated with regulations for modifying susceptibility to flooding), the aggressive application of postflood recovery measures, and by extensive public awareness and education efforts.

Awareness of the relatively new fourth strategy of restoring and preserving floodplain natural resources has grown, which is a first step toward fuller implementation of the strategies and its tools. It will be particularly important for this strategy to be more thoroughly integrated with the others in the future, both in concept and in practice.

Shortcomings can be pointed out in virtually all of the tools and strategies for floodplain management, in the ways they have been implemented, and in the existing management framework itself. The program fragmentation, conflicting goals, lack of funding, overlaps, omissions, and other deficiencies typical of any program of this magnitude and ambition have contributed to a lower level of integration and accomplishment than is desired and possible. Hence, there is much work left to be done, and numerous opportunities for improving the effectiveness of the Nation's floodplain management efforts already have been identified. Some ideas for taking advantage of these opportunities are discussed in the next, final chapter.

CHAPTER 16:

OPPORTUNITIES FOR INCREASING THE EFFECTIVENESS OF FLOODPLAIN MANAGEMENT

... [T]here are a number of trends on the national scale that make floodplain management intricate and require flexible methods ... [T]he national program as a whole must be alert and flexible in dealing with new conditions as they arise.

"Action Agenda," National Review Committee, 1989

This chapter highlights some of the ways in which floodplain management may be improved in the coming years. Although specific recommendations are not presented (these will require additional attention and study), examples of the sorts of actions and initiatives that can be carried out to make floodplain management more effective are described. Many of these actions and initiatives have been suggested by government agencies and other observers of floodplain management. Many involve efforts to better implement the existing strategies and tools as set forth in the report *A Unified National Program for Floodplain Management* as updated by the Federal Emergency Management Agency (FEMA) in 1986. The discussion begins with the broadest opportunities and proceeds to the more specific.

SETTING MEASURABLE AND ACHIEVABLE GOALS

Floodplain management would benefit from a set of goals meant to be achieved by a certain date and whose degree of achievement can be measured. Strong, clear, measurable goals help develop constituencies for the programs they guide (U.S. Environmental Protection Agency, 1990). The goal set in the 1972 Clean Water Act of having all the Nation's rivers and lakes "fishable and swimmable" by 1983 was thought to have been partly responsible for the high levels of funding and significantly improved water quality over the past 20 years, even though the goal itself was not reached. Another example is the "no net loss of wetlands" goal developed by the National Wetlands Forum and endorsed by President Bush (Sheaffer, 1989). Several organizations and agencies have suggested specific goals, presented on the following pages, to better guide and focus national floodplain management efforts. Note that not all of the goals suggested would be readily or precisely measurable.

The Bureau of Reclamation (BOR) has suggested that goals for the year 2000 and beyond should include the management of the natural resources of floodplains in conjunction with loss reduction efforts and that it would probably "be necessary and desirable" for governments to enter into partnerships with private organizations to achieve that goal (Bureau of Reclamation, 1989).

The American Red Cross has recommended goals of: 1) moving people out of areas where they are continuously threatened by flooding; 2) providing better flood loss reduction programs, such as wet and dry floodproofing; and 3) providing community education on personal and family safety and flood hazard in general (Vessey, 1989).

The National Review Committee has identified two existing national goals — to 1) reduce the vulnerability of all Americans to the danger and damage of floods; and 2) preserve and enhance the natural functions of the Nation's floodplains — and has noted that these goals need to be clarified and harmonized, even though it will be a difficult task. Nevertheless, the committee notes that "appropriate management shared by the agencies involved in ways that can be measured" could result in reconciliation and achievement of the two goals (National Review Committee, 1989).

Goals suggested by the U.S. Army Corps of Engineers (Corps) include: 1) increasing funding for federal programs that directly contribute to a balanced floodplain management program; 2) enhancing public awareness, arousing social consciousness, and successfully marketing the concept of floodplain management; and 3) achieving a balance among conflicting interests for the use of land and water resources (U.S. Army Corps of Engineers, 1989).

Several observers have noted the need for reducing losses to existing buildings and infrastructure. There is strong support for using structural measures to protect existing facilities and for increased efforts to floodproof and retrofit existing buildings. The SCS has suggested increased forecasting and warning efforts in combination with individual residential and business flood-response plans (Soil Conservation Service, 1990). The National Review Committee has suggested the issuance of a new federal executive order requiring all federal agencies to assess the vulnerability of federal facilities to flooding as well as the vulnerability of those state and local facilities constructed with federal aid. A report would be submitted to the President and to Congress recommending appropriate steps to protect federal facilities from flooding. The Federal Interagency Floodplain Management Task Force could recommend and draft such an executive order (National Review Committee, 1989). Full implementation of the Community Rating System (CRS) of the National Flood Insurance Program (NFIP) should also help to reduce losses to the existing stock of floodprone structures. Changing the provisions of flood insurance policies to exclude coverage for most basement contents has helped reduce repetitive loss claims, but additional measures are needed. As one way of attacking this problem, FEMA has recommended that the Internal Revenue Service's casualty loss regulations be modified (Federal Emergency Management Agency, 1989), perhaps by limiting them to areas outside the designated "100-year" floodplain or by reducing or eliminating deductions for repetitive losses.

FEMA's Federal Insurance Administration (FIA) has established eight goals for the U.S. Decade for Natural Disaster Reduction: 1) broaden the geographic spread of the insurance policy base and strengthen the enforcement of the mandatory purchase requirement; 2) mitigate existing risks by establishing a mitigation evaluation system for repetitive loss and substantially damaged structures;

3) complete deployment of an effective, comprehensive community rating system; 4) assure multi-hazard compatibility of flood loss reduction standards; 5) digitize flood insurance maps; 6) address special area management programs such as for alluvial fans and coastal erosion areas; 7) strengthen the Unified National Program for Floodplain Management; and 8) strengthen the National Flood Insurance Program financial base to meet the catastrophic flood (Federal Emergency Management Agency, 1990). These goals are in concert with the goals of the U.S. Decade for Natural Disaster Reduction to stimulate activities that will minimize the impact of natural disasters on the Nation.

Another goal that has been mentioned is that of reducing losses to areas and structures outside regulated floodplains. One way to reduce stormwater flooding losses in areas outside the "100-year" floodplain is to require floodplain regulations in all areas where flood insurance is available. This approach is supported by the Association of State Floodplain Managers (ASFPM), which recommends the identification and regulation of stormwater flooding areas. It can be argued that it makes little sense to insure, but not regulate, structures flooded by stormwater (Larson, 1989).

IMPROVING THE DATA BASE

A more complete and reliable data base for floodplain management will increase the capabilities of agencies to evaluate the effectiveness of their programs, allow groups such as the Federal Interagency Floodplain Management Task Force to better assess the Nation's collective floodplain management program, and give local government leaders more opportunities to identify the public risks and costs associated with floodplain development.

The obstacles to developing and maintaining an adequate data base are substantial. Important determinations must be made about the type of data to be collected, how often it should be collected, by whom, and using what criteria. Adequate funding must be found.

Information from FEMA's flood insurance data base could be added to national flood damage estimates. It may be important to distinguish agricultural damages from other flood damages, and to distinguish coastal flooding damages from riverine damages. The consensus of an interagency seminar on flood loss data was that the more categories of data there are, the more meaningful the information will be to different users (von Wolffradt, 1990).

Recent advances in the development and application of geographic information systems (GISs) can improve the data base. With these systems, layers of information, such as that from flood insurance maps, cultural resource maps, and the TIGER data system of the U.S. Census Bureau, can be combined for display, analysis, and management applications. Use of a GIS also can expedite and support local floodplain management decisions.

The American Planning Association has suggested that the federal government support the collection of data to demonstrate the adverse economic impact of floodplain development on public sector investments (Smith, 1989). This would help local officials who are responsible for controlling private development to identify the public risks and costs associated with floodplain occupance.

NEW RESEARCH

To improve the data base, additional research should be conducted on several important topics.

> *The National Science Foundation should be requested to consider funding research to examine, in a selected sample of communities, the full benefits and costs, both public and private, of floodplain occupancy and associated floodplain management measures, having due regard for national productivity, the impacts on natural values, and the equitable distribution of costs and benefits* (National Review Committee, 1989).

A related research topic would be evaluation of the economic benefits of floodplain management. This would include an identification of the monetary benefits derived from maintaining the natural uses of the floodplain, including benefits associated with reduced flood losses, increased recreational opportunities, and reduced costs for water quality maintenance (U.S. Environmental Protection Agency, 1989).

It has also been suggested that 10-20 areas in the Nation be identified where the potential for flooding is highest and the potential impacts most catastrophic, and that special studies be undertaken to determine steps needed to reduce the potential losses from catastrophic events affecting these areas.

Information about flood risks could be improved by mapping all areas subject to flooding, including drainage basins under one mile square, and by adding to flood risk maps provisions for future land-use changes that will increase peak discharges.

The Association of State Floodplain Managers has developed and published a list of research needed to improve state and local floodplain management efforts (Larson, 1989). The suggestion has also been made that a national plan for floodplain management research be developed and implemented, and that particular emphasis be placed on devising means to fund and carry out the research (Owen, 1989).

IMPROVING THE MANAGEMENT FRAMEWORK

Members of the Federal Interagency Floodplain Management Task Force, which developed and refined the Unified National Program for Floodplain Management in report documents issued in 1976, 1979, and 1986, have indicated that the conceptual approach presented in the current program should be considered as still evolving and not yet achieved in practice (Federal Emergency Management Agency, 1989). The same could be said for the rest of the management framework — the legislation, agency policies, judicial support, coordination, economic constraints and incentives, and other components. A good start toward improving the framework could be made by sharpening the focus of the national effort with a clear definition of floodplain management, a set of goals, and a workable plan for achieving them. With that foundation, any remaining components in need of refinement will be more easily identified and made operational. Some specific opportunities are described on the following pages.

INTEGRATE STRATEGIES FOR FLOOD LOSS REDUCTION AND FOR RESTORING AND PRESERVING NATURAL RESOURCES

Flood loss reduction and natural resources protection should be better integrated in theory and practice to make floodplain management truly effective. This will require: a general rethinking of the two concepts and how they can and should relate to each other; a possible reformulation of goals for each as presented in *A Unified National Program for Floodplain Management*; and work at all levels to minimize actual and potential conflicts between the two strategies as they are applied to real situations.

Federal agencies can lead the way by identifying opportunities within the context of existing programs to better maintain the natural resources of the floodplain. State and local units can do likewise (U.S. Environmental Protection Agency, 1989). The Wildlife Management Institute (WMI) has suggested that conflicts can be resolved "through integrated management approaches and practices designed through interdisciplinary teams, including ecologists, biologists and natural resource managers" (Jahn, 1989). The WMI has also suggested that a "white paper" be prepared and distributed to elected officials throughout the country in order to "emphasize the needs and opportunities for action."

The National Association of Conservation Districts (NACD) has suggested that a joint commission or committee of federal, state, local, and private interests be established in each state to identify potential problems and develop plans and priorities to solve them (Sprague, 1989).

A member of the National Association of Flood and Stormwater Management Agencies has suggested that "with respect to organizational approaches at the federal, state, and local level that would better accomplish flood loss reduction and maintenance of natural values, probably the most productive accomplishment would be consistency in criteria between agencies in the same level of government together with a better appreciation of the respective needs of the various agencies" (Tidemanson, 1989).

The National Association of Water Institute Directors has suggested an even broader approach:

> *You cannot separate floodplain management from the other objectives of land and water resources management to specify an organizational structure that will achieve this objective by itself. Rather, floodplain management, flood control, stormwater management and related activities have to be carried out in combination with an integrated water resources management strategy. Such a strategy requires a clear definition of roles at the different levels of government and by the different functional organizations responsible for water management ... A statement of organizational structure for floodplain management alone is overly simplistic, but there needs to be some attention given to the integration of floodplain management with other water resources activities* (Grigg, 1989).

IMPROVE COORDINATION AND INTEGRATION

Many observers have pointed out the need for improving the integration of all aspects of floodplain management as well as coordination and cooperation among the agencies and groups with floodplain management responsibilities. The Federal Interagency Floodplain Management Task Force and the Association of State Floodplain Managers could work together and with others to expand their efforts to achieve these objectives.

Some of the conflicts among federal programs can be reduced or eliminated by administrative action. Several conflicts result from differing attitudes and expectations about the ultimate responsibility and commitment of resources to respond to flood problems. Many have their origins in the legislative mandates of the different agencies with floodplain management responsibilities, and they will be more difficult to address. The agencies have only limited ability and incentives to pursue the types of legislative and institutional changes that would reduce or eliminate some of the more significant program inconsistencies as well as the overlaps, gaps, and conflicts that affect the national program. Much of the impetus for the changes that will be needed to reduce conflicts will come from outside sources, such as the ASFPM, the Association of State Wetlands Managers, the Coastal States Organization, and the Association of State Dam Safety Officials (ASDSO).

IMPROVE COOPERATION

Some observers believe that building on the cooperation that already exists among floodplain management agencies at all levels is the best way to improve floodplain management effectiveness (U.S. Department of Agriculture, 1989). Interstate and inter-county water basin planning can be encouraged to address interjurisdictional problems (U.S. Environmental Protection Agency, 1989). The Federal Interagency Floodplain Management Task Force has a special leadership role, and can develop recommendations for maximizing the integration of the diverse strategies and tools into a coherent national approach (Federal Emergency Management Agency, 1989). One observer has suggested that federal agencies need greater coordination at the regional level, where "turf battles" are often greater than at headquarters. Suggestions for promoting this improvement include interagency sponsorship of committee symposia and workshops at the regional level to promote the integration of diverse floodplain management interests.

The Corps has commented that an adequate and functioning organizational structure is in place at the federal level and in some states but that "no single entity is accountable or has the responsibility for accomplishing all of the floodplain management goals. The national policy should be consolidated in a clear, concise document that outlines the responsibilities at federal, state, and local levels of government and establishes a high degree of coordination to formulate an open and participatory process that encourages active involvement" (U.S. Army Corps of Engineers, 1989).

One Corps representative has suggested, however, that "to fully realize the benefits of floodplain management at the federal level, some form of water resources coordinating body, along the lines of the now defunct Water Resources Council, must be established with a mission of addressing these issues. While its performance may have been spotty, the existence of the council, at a level above the departments and agencies, provided a vehicle for taking on the 'bigger' issues including the role of the Congress. These issues are shunned by interagency task forces. Similar approaches must be taken, where appropriate, at the state level, to assure inter-state coordination" (Galloway, 1989).

An example of positive interagency and intergovernmental coordination is the formation and function of professional groups, such as the Association of State Floodplain Managers and the Association of State Dam Safety Officials. State coordinators of the National Flood Insurance Program formed the ASFPM in the 1970s to represent state floodplain management interests in their dealings with the newly created Federal Emergency Management Agency, which at the time was viewed as an agency oriented toward defense and civil preparedness with relatively little interest in floodplain management activities. From an initial adversarial relationship grew an important spirit of cooperation and coordination that has advanced floodplain management greatly over the past decade (Accurti, 1988). The cooperative efforts of federal, state, and local officials as members of the Interagency Committee on Dam Safety (ICODS) have been beneficial to floodplain management. The ASDSO and the ICODS meet formally once a year and coordinate throughout the year through subcommittee work (Spragens, 1989).

ALLOW DIFFERENT APPROACHES

In attempting to devise and implement a truly national program, special situations sometimes are overlooked. Many floodplain losses are of a sort that simply cannot be addressed through a "by-the-book approach." The management framework must remain flexible enough to permit any effective approach, including those described below.

Management of High Risk Flood Hazard Areas

Because the minimum floodplain management standards of the NFIP do not include management techniques for such high risk flood problems as ice jams, flash floods, coastal flooding and erosion, mudslides, ground failure, alluvial fans, fluctuating lake levels, moveable stream beds, and areas behind unsafe levees or below unsafe dams, most local programs simply do not address these hazards. It has been suggested that the National Science Foundation and the interested federal agencies jointly fund a program to develop methods for identifying, mapping, and regulating areas with special flood hazards (National Review Committee, 1989). This type of preflood planning could identify alternatives available to a community to reduce future flooding and protect the natural and cultural resources of its floodplains.

In the absence of such a program, definite progress still has been made over the past few years in addressing these areas. Some states faced with these hazards — particularly in the arid West — have worked cooperatively with FEMA to better understand and define the hazards and to develop flexible and innovative approaches for effective management. Participants at a workshop held during the 1988 Annual Conference of the Association of State Floodplain Managers to address high risk flood hazards concluded that "... while more research aimed at understanding natural processes is needed, the focus now should be on developing state and local strategies using existing information" (Association of State Floodplain Managers, Workshop #10, 1988).

Incentives for communities to map and regulate high risk hazard areas are now being provided through the Community Rating System of the NFIP. Studies are underway to identify more creditable methods for mapping and managing these areas. Development of new mapping, management, and regulatory standards will require increased time and effort, but relatively simple interim standards may be effective in the meantime (Bond, 1990).

Broader Management Approaches

The conditions that cause floods and influence the impacts of flooding do not recognize the political boundaries by which most floodplain management techniques are applied. Many professionals believe that a comprehensive management approach based on hydrologic units and encompassing entire watersheds must be made a higher priority, especially if the natural resources of the hydrologic units are to be protected. The efforts of river basin commissions, the U.S. Environmental Protection Agency's National Estuarine Sanctuary program, and the National Park Service's State and Local River Conservation Assistance Program are examples of this type of comprehensive basin approach.

Others have suggested that in order to achieve widespread development of floodplain management plans, legislation is needed to provide states and communities with the opportunity to develop plans that meet federal guidelines. The federal Coastal Zone Management Act was offered as a model for such a program. The major advantages of such an approach would include voluntary participation, federal financial assistance for participating states to help cover the costs of preparing state and local floodplain management plans, and a "consistency" provision whereby actions of federal and state agencies would have to conform to approved local floodplain management standards (Burby, 1989).

Participants in a workshop held during the ASFPM's 1988 annual conference suggested that community programs related to economic development and water quality have the greatest potential for implementation in combination with flood loss reduction efforts. "Economic redevelopment projects were judged important because they provide tangible community benefits of new jobs and an increased tax base. Combining floodplain management with water quality maintenance, particularly through nonpoint source control projects, was seen as a logical combination in that many projects of this type would not require expensive maintenance" (Association of State Floodplain Managers, Workshop #5, 1988).

To facilitate broader management approaches, the states could enact legislation providing for regional or watershed management, for river corridor management, and for other regional efforts based on hydrologic and other natural boundaries rather than political jurisdictions. Authority for such regional approaches could rest with a state agency or be delegated to a regional entity, or even to counties or cooperating communities.

- **Watershed Management.** Watershed management has been applied in areas involving several communities and, in some instances, metropolitan areas. Sophisticated watershed models reflecting various development patterns provide analytical bases for planning and effective management. Although expensive and time-consuming to develop, the use of these models can often be justified for rapidly developing areas and they will probably continue to be used in the future. More accurate identification of the impacts of development and other actions on flood risk and vulnerability throughout the watershed can help in the design of management approaches ranging from onsite detention basins to broader area-wide measures. Water quality issues are expected to be of increasing concern to floodplain managers working within watershed management programs.

- **River Corridor Management.** Over the past two decades, better procedures have been developed to identify and document the cultural and natural resources contained within river corridors, and to analyze potential impacts to these resources. Over the past two decades environmental legislation has supported river corridor management, as has the expansion of interdisciplinary and intergovernmental cooperation. Because most riverine wetlands are located within floodplains, wetland managers, floodplain managers, and other natural resources managers are discovering that they have many common interests and needs. In addition, the President's Commission on Americans Outdoors made special note of the importance of stream corridors for outdoor recreation. Proposed legislation to facilitate better multi-objective river corridor planning and management was introduced in the last session of Congress, indicating that interest and support for river corridor management is growing at that level as well.

Considering Local Conditions

The National Review Committee and other observers have noted the importance of incorporating awareness of local conditions into the national program. Prescribing uniform national standards for the preservation, use, and development of floodplains and other hazard areas for application at the local level can create the potential for inefficient allocation of resources and social inequities. The Review Committee has suggested that federal agencies examine the practicality of using performance standards, based on national standards and implemented through local watershed and floodplain management programs, to achieve floodplain management goals. If performance standards are applied, however, care should be taken to ensure that they do not lessen the existing federal limits on permissible vulnerability in the floodplain.

Communities should be encouraged to adopt flood hazard mitigation measures particularly suited to their local circumstances (National Review Committee, 1989). Adoption and implementation of the Community Rating System within the National Flood Insurance Program may encourage communities to do this. The CRS can recognize the need to reconcile loss reduction, public safety, and environmental objectives.

Helping Rural and Economically Disadvantaged Areas

It is increasingly important to find special ways to improve floodplain management, including natural resources protection, in small rural communities and economically disadvantaged areas. Many of the existing floodplain management tools are more appropriately applied in communities with fairly high standards of living. Priorities for natural resource preservation are virtually nonexistent in low-income communities where a resident cannot even count on the availability of potable water or sanitary facilities during and after a flood. Certain legislation, agency policies, and federal guidelines require that a positive benefit/cost ratio be shown before federal funding can be obtained for structural or nonstructural flood control projects. This requirement often excludes small rural communities and owners of inexpensive homes from participating in these projects because in areas with low property values it is often difficult to demonstrate that flood control projects will yield enough economic benefit to offset the costs of construction, acquisition, or other expenses, even though the social benefits may be high (Galloway, 1989).

The Soil Conservation Service has observed that the Community Rating System will primarily benefit individuals in communities that have the staff and resources to complete the required paperwork and implement programs that exceed the minimum NFIP requirements (Soil Conservation Service, 1989). Many small and rural communities may not be able to take advantage of this program because of their limited staff and resources.

Certain rural and economically disadvantaged communities, particularly those with a high incidence of flood losses per capita, should be targeted for special attention. States can provide floodplain management services to them through funding from the Federal Emergency Management Agency's Community Assistance Program (CAP). States could also direct floodplain management services to regional entities or to "circuit-riding" staffs that serve several communities under a contractual arrangement. Creative means should be employed to provide needed levels of assistance to part-time, volunteer, or unpaid staff and officials in rural areas.

In addition, new initiatives should be aimed at reducing flood losses to agricultural and forest resources, which are the most prevalent floodplain land uses, particularly in rural areas. According to the 1982 National Resources Inventory data (Table 1-1, page 1-4), over 90% of the nonfederal floodplain lands inventoried are in cropland, pasture, rangeland, and forestry. The Second National Water Assessment (U.S. Water Resources Council, 1975) (the most recent data available) showed that 50% of flood damages are to agricultural resources. Labor-intensive agricultural uses, such as vegetable farming, cotton, and corn farming, will suffer considerable losses if flooded during the growing season. In most cases, the nonintensive uses such as forestry and grassland should be considered compatible land uses on rural floodplains.

Encouraging the "Best Mix" of Floodplain Management Measures

Several agencies and observers have identified the need for incentives to achieve the best mix of floodplain management measures.

The U.S. Environmental Protection Agency (EPA), for example, would like to see "a program of federal, state and local incentives to conserve floodplain values and minimize potential property and life losses as well as disincentives to discourage development that is incompatible with the natural and beneficial values of floodplains" (U.S. Environmental Protection Agency, 1989). The Association of State Floodplain Managers has carried this thought one step further and observed that "the multi-objective approach that has been used successfully in a few local programs in the nation will only blossom if some federal actions are taken to remove cross program conflicts and provide appropriate incentives" (Larson, 1989).

The Federal Interagency Floodplain Management Task Force can contribute to the 'best mix' by sharing information on the agencies undertaking nonstructural damage reduction activities as well as information about the funding available for such activities (National Review Committee, 1989).

IMPROVING THE FLOODPLAIN MANAGEMENT STRATEGIES AND TOOLS

The four strategies for managing the Nation's floodplains and the tools for implementing these strategies appear to cover the gamut of currently possible approaches to the general goals of halting or reducing floodplain losses. If new goals are set over the next few years, the strategies and tools may need to be re-examined to determine whether additional strategies and tools are needed. Meanwhile, it is generally agreed that additional progress could be made in floodplain management with better or more extensive application of the existing strategies and tools. Some opportunities for improved application are described below.

MODIFYING SUSCEPTIBILITY TO FLOOD DAMAGES AND DISRUPTION

In the long run, preventing as many floodplain losses as possible is the most effective and efficient way of dealing with the flood hazard. Because of this, modifying the Nation's susceptibility to flood losses may prove to be the wisest and most widely used strategy in the coming decades, and it is likely that new tools will be developed to implement this strategy. In the meantime, there are numerous ways to improve the effectiveness of the tools that already exist.

Regulations

Improved enforcement of floodplain regulations by local governments will in large part depend on reducing local apathy and negative attitudes about floodplain management. State and community support for local regulations as well as the imposition of penalties for lack of enforcement are essential. Incentives for improved enforcement should be strengthened and disincentives eliminated. To facilitate improved enforcement, the federal government and the states should assist local officials in understanding data requirements and the proper procedures to be followed in administering floodplain regulations.

There are several measures that can help reduce the usually unfounded concern of local and state officials that strict floodplain regulations will be challenged as unconstitutional "takings" of private property. More information should be provided to state and local officials, and to the attorneys that advise them, so that they can better understand the types of actions that are likely to be judged takings and those that are not. The Federal Emergency Management Agency, the Association of State Floodplain Managers, and others can distribute information to the states and communities.

Development and Redevelopment Policies

Minimizing flood damage to existing infrastructure will ensure the continual operation of vital community services. Because the location of new infrastructure in the floodplain can encourage the use and development of hazardous areas, it is particularly important that infrastructure that must be located in or near the floodplain be properly designed and regulated.

The potential adverse impacts of infrastructure decisions on flood vulnerability should be minimized. The operation and maintenance of existing infrastructure should be continually evaluated for its potential impact on floodplain use. The mitigation of possible future damages should be provided when relocating, restoring, replacing, or repairing flood-damaged infrastructure and facilities.

MODIFYING FLOODING

Although the strategy of modifying flooding may be incompatible with some environmental protection objectives, structural measures still have important roles to play in comprehensive floodplain management programs. There is an opportunity now to reformulate this strategy to acknowledge the importance of preserving and restoring the natural and cultural resources of floodplains. Some of the tools to implement this strategy, such as land treatment measures and onsite detention, can be important components of comprehensive floodplain management and resource protection programs, and should be emphasized.

Structural shoreline protection measures, not included as a tool to modify flooding in *A Unified National Program for Floodplain Management*, may be considered for inclusion under this strategy. The movement of the Nation's population toward coastal areas, the incorporation of erosion-induced flooding into some existing programs, and the prospect of rising sea level make this an opportune time for pondering the feasibility of such measures in comprehensive programs.

MODIFYING THE IMPACT OF FLOODING ON INDIVIDUALS AND COMMUNITIES

It is not surprising that most of the perceived opportunities for modifying the impact of flooding are directed toward broadening the awareness and knowledge of flood hazards on the part of local officials, professionals of all types, and the general public. Without widespread awareness and continually updated information, none of the tools or strategies for floodplain management can be effectively implemented.

PUBLIC AWARENESS AND EDUCATION

The need for improved information and education is highlighted by the following comments and suggestions from a broad spectrum of agencies and groups involved with floodplain management.

- The National Committee on Property Insurance has stated that "public education and awareness programs are ... essential" (Cogswell, 1989).
- Both the American Planning Association (APA) and the All Industry Research Advisory Council (AIRAC) have commented on educational needs at the local level. The APA believes that sophisticated educational materials should be provided for the local officials and citizens affected by floodplain controls. These materials could help build the public support necessary for local floodplain management efforts (Smith, 1989). The AIRAC has emphasized the value of educational materials to inform local decision-makers and the public about the importance of floodplain management (Unnewehr, 1989).

- The Soil Conservation Service has noted that local officials, the public, and most of all, developers need to be better educated about the hazards of developing floodprone areas. To this end, the SCS has recommended increased publicity about the dangers and consequences of flooding, including more graphic detail of potential water depths, velocities, and probable damages. For example, the high water lines of past floods could be prominently displayed in public places to call attention to the flood hazard (Soil Conservation Service, 1989).

- The Soil Conservation Service also has pointed out the need for a better coordinated interagency public information program to increase awareness of flood hazards. It is expected that many communities, particularly rural ones, would take additional measures to protect themselves if more flood hazard information was made available to them. To increase the information exchange, interagency brochures should be used and video presentations prepared for television and/or presentation to local groups and organizations (Soil Conservation Service, 1991).

- The Federal Emergency Management Agency has suggested that to reduce false-expectations lawsuits, insurance rating and compliance information be filed with the property deed to assure that the current owner and future buyers of floodprone property are fairly warned of flood risk (Federal Emergency Management Agency, 1989).

- The National Review Committee has suggested that federal agencies take appropriate actions to increase information and education. For example, "... the interagency task force and its member agencies should continue, expand, and evaluate efforts to inform and educate the public about the nature of flood hazards, the natural values of floodplains, and the various strategies and tools available for comprehensive floodplain management" (National Review Committee, 1989).

- The Association of State Floodplain Managers supports increased information and education, but also believes that to sell citizens and communities on flood loss reduction, it is important to present the value of floodplain management as one element of a broader concept or package that addresses a number of other local problems as well (Larson, 1989).

- The American Planning Association has suggested demonstration projects to show how floodplain management fits into other community planning objectives. These demonstrations could show how communities can use floodplain management techniques to complement open space protection programs, help ensure good ground-water supplies, provide recreation facilities, and meet other goals (Smith, 1989).

- The Environmental Protection Agency has described the need to widely distribute examples of innovative solutions to floodplain management problems. Furthermore, the EPA believes that a regular exchange of ideas and solutions among developers, planners, and floodplain managers is important and that federal agencies can do much to foster this exchange and increase awareness through publications, training programs, and conferences (U.S. Environmental Protection Agency, 1989).

- The National Park Service has suggested that its regional offices and state river conservation managers continually provide information and consultation about existing and potential wild, scenic, and recreational rivers. This information can be provided to federal, regional, state, and local offices and programs that affect floodplain management.

Training and Education for Government Officials

To help counter the impediments to local floodplain management created by the rapid turnover of elected and appointed public officials, regular opportunities for floodplain management training and education should be provided. For the most part, state agencies, through agreements with FEMA and on their own, are currently providing most of the training of local officials and will probably continue this function. Federal agencies and programs could increase their training and education-related assistance to the states, and the states could become more active in providing similar assistance to local governments. Improved training programs are needed for code administrators, planners, inspectors, public works directors, and other local government personnel directly involved in floodplain management (Smith, 1989). The Corps of Engineers has suggested that the states establish committees of state, local, and federal representatives to work on education, increasing awareness, and promoting floodplain management (U.S. Army Corps of Engineers, 1989). More information also should be provided to state and local officials about the types of regulatory actions that are likely to be judged "takings" and those that are not.

At the federal level, it has been suggested that the Federal Interagency Floodplain Management Task Force develop training programs and conduct regional training exercises at reasonable costs for appropriate government personnel (National Review Committee, 1989).

Flood Insurance

In order to expand the premium base and move the National Flood Insurance Program closer to a fully actuarial basis, the number of insured structures must be increased by a combination of actions, including expanding the market penetration, insuring structures outside the floodplain, enforcing the mandatory purchase requirements, increasing awareness of the flood hazard, and keeping premiums at a low, affordable rate.

Postflood Recovery

The immediate application of all available resources to implement mitigation measures after a flood — while the affected population can still see the need for change — can help to prevent recurring losses. To do this, predisaster planning is essential. Such planning could include the identification by communities of repetitively flooded structures, or making a list of persons or firms with expertise to help local building officials assess structural damage and oversee rebuilding after the disaster. The states could establish technical assistance teams of representatives from various state agencies to be mobilized in a disaster, dispersing throughout the area to identify mitigation opportunities and encourage action.

Careful attention must be given to ensuring that funding for postdisaster mitigation as authorized by the Disaster Relief and Emergency Assistance Amendments of 1988 and other sources of funds are used creatively and completely. State and federal agencies can help local governments apply for the funds, and the recommendations of the postdisaster interagency hazard mitigation teams should guide their use.

RESTORING AND PRESERVING THE NATURAL AND CULTURAL RESOURCES OF FLOODPLAINS

As noted in Chapter 15, the limited implementation of this strategy sets the stage for a close re-examination of it both conceptually and operationally. Is it really two strategies — restoration and preservation — as described in *A Unified National Program for Floodplain Management*? If so, are the same tools appropriate for both? Are the strategies really goals?

It may be that some of the tools assigned to this strategy are inadequate to carry it out today, given the fact that potentially more effective approaches — comprehensive river corridor management, endangered species protection, and water quality maintenance approaches, for example — are already underway outside the framework of floodplain management. If that is the case, then the tools from the other, effective programs need to be examined closely, borrowed, and tailored to floodplain management needs. In any case, this strategy could be much more thoroughly integrated with the other tools and strategies and with compatible efforts in other fields. For example, there may be a great potential for coordinating plans for restoring and preserving the natural and cultural resources of floodplains with postdisaster recovery efforts, or with wetland protection programs.

The Federal Emergency Management Agency has suggested that:

> *The solution to [lack of awareness of natural floodplain resources] is not in re-writing statutes to be more environmentally sensitive, but in educating decision makers and practitioners on natural floodplain functions and the need for creative solutions. The solution then is to teach them correct principles and to let them govern themselves. The current trend toward mitigation solutions, for example, could be complemented by training workshops and manuals on incorporating environmentally sensitive design into mitigation projects ... Information ... would include promotional information, benefit cost data and technical assistance regulations* (Federal Emergency Management Agency, 1989).

SUMMARY AND CONCLUSIONS

A number of important opportunities are emerging for improving the effectiveness of floodplain management in the United States. If current trends continue, the near future will see a further broadening of the scope of floodplain management to encompass such activities as stormwater management, greenway and river corridor management, and watershed management. Further integration of individual strategies and tools is likely, so that a more unified program can emerge, with fewer conflicts among goals and activities. The floodplain management framework itself will continue to be examined and tailored so that its components are as appropriate, consistent, and well coordinated as possible. Technological advances hold great promise for improving the application of existing strategies and tools. An additional avenue of opportunity is the likely future integration of flood loss reduction strategies and measures with those designed to manage other natural hazards, such as ground subsidence, dam failure, earthquakes, and hurricanes.

This report on the Nation's floodplain management activities — the first comprehensive assessment in over 25 years — has identified a plethora of actions to be pursued if significant improvements are to be made in floodplain management in the coming decades. Of these, two are of paramount importance. First, the concept of floodplain management needs to be simplified. Second, a set of specific goals needs to be placed on the national agenda, along with a timetable for their accomplishment. These two needs should be addressed as the Federal Interagency Floodplain Management Task Force undertakes to further refine the Unified National Program for Floodplain Management.

PART VI:

EPILOGUE

Gilbert F. White was invited by the Federal Interagency Floodplain Management Task Force to provide a closing comment — which he entitles "Retrospect and Prospect" — for the *Assessment Report*. His Doctor of Philosophy dissertation *Human Adjustment to Floods, A Geographic Approach to the Flood Problem in the United States*, was prepared in 1942, and first proposed a broad, integrated approach to solving the Nation's flood problems. It stimulated the interest and set the course for the emergence and evolution of floodplain management during the ensuing decades. In the 50 years since his study, Mr. White has, in countless ways, remained actively involved in facilitating and promoting the floodplain management mission.

RETROSPECT AND PROSPECT

an invited comment by Gilbert F. White

This Assessment is unprecedented in its depth of analysis of the nature and effectiveness of the nation's management of floodplains. It is the most detailed and nearly comprehensive of all studies of those matters since the concept of floodplain management took official root in the mid 1960s. It places that concept in a broader context than ever before, and it provides a base for launching a series of steps to assure that local and State as well as Federal programs can at last approach the aspirations that have evolved over the past 65 years.

That evolutionary process has been reflected in a stream of laws, executive orders, regulations, new groups, and reports. Debate over the wisdom of reliance on simple levees and channel modifications began in the wake of the 1927 flood on the Lower Mississippi. It widened to include issues of dams and economic justification after the Ohio River floods of 1936 and 1938, and a concurrent upstream versus downstream controversy over land treatment. By 1966 a still broader view of the potential role of nonstructural measures found favor. Then followed a series of revisions and expansions of Federal and State activities. Those included the National Flood Insurance Act of 1968, a National Science Foundation appraisal of flood research in 1977, a Unified National Program for Floodplain Management in 1976, with revisions in 1979 and 1986, three Executive Orders, a formal linkage with emergency management programs, and the organization of vigorous nongovernment groups such as the Association of State Floodplain Managers and the Association of State Wetland Managers.

All of this and much more is examined in the Assessment. To sum up, the report tells the country what has been happening in floodplain management; how well or how poorly the responsible Federal and State agencies have been doing; and, what are promising means of improving the prospect. The result is the first thorough appraisal of ambiguous national aims and how those compare with the present situation on the lands at risk -- the diverse areas of watercourses, adjacent wetlands, and the shores of streams, lakes, and oceans.

The report candidly recognizes the severe handicaps of incomplete and inconsistent collection of data on which policy judgments must be based. The data base is the one need specified in the 1966 House Document on which almost no action has been taken.

For other needs, the record of change has been diverse but generally positive. In no instance, however, has achievement matched the hopes of earlier years. The definition of precisely what is meant by floodplain management in particular areas of the country or under the jurisdiction of specific agencies is still far from clear or uniform in either principle or practice. The policy goals for the sustainable use of floodplains have progressed in agency thinking but are proving difficult to meet in operation in the field. It has not been made clear how floodplain use is inseparably linked to the maintenance of natural resources for the common good for the foreseeable future. The effectiveness of individual Federal and State programs, each with a different statutory authority, suffer thereby.

Cooperation among the administrators of Federal programs, while generally cordial and helpful, has not yet yielded a genuinely unified effort. Lacking exemplary effectiveness at that level, State and local agencies cannot be expected to act in concord in meeting national goals.

Great gains have been made in public information and education. Far more legislators, administrators, business executives, farmers, householders, and school children are aware of flood hazards than a decade ago. The level and quality of information, however, still is far below what would be required to induce effective action in the event of a threatening flood, and even more so in the days when measures are needed to mitigate future emergencies.

Flood forecasting precision has generally improved. The demonstrated ability of communities to respond positively to a warning is less certain, and is uneven.

The report suggests lines along which improvement can be brought about, and recommends consideration of a number of changes in policy and procedure. The Report's Review Committee does likewise with its <u>Action Agenda for Managing the Nation's Floodplains</u>. These must be examined now against the background of experience with previous statements of optimal floodplain policy, such as House Document 465 or the <u>Unified National Program for Floodplain Management</u>. Only fragments of those proposals were adopted. Can anything be learned from the conditions that either promoted or blocked them? What are the factors in climate of public opinion and in government organization that worked for or against them at that time and that may have changed subsequently?

It is evident that the reconciliation of thinking among professional groups, for example, has been advanced by research, conferences, training, and publications. Hydrologists, engineers, geographers, economists, land planners, ecologists, city managers, insurance executives, and disaster relief directors, among others, now are speaking the same language. But there are at least three directions in which lessons learned are still not practiced.

One important lesson was that quick and nation-wide change in procedures without careful trial in selected areas and without subsequent critical appraisal can be counter-productive. When the Tennessee Valley Authority established its community assistance program for flood damage prevention planning in 1953 and the Corps of Engineers introduced its floodplain management services program in 1960, they moved cautiously and employed a variety of trial approaches. In contrast, when national flood insurance was introduced in 1968 there was a brave commitment to offer coverage to all parts of the country at once. Little attention was given to post-audits of the rates, terms of insurance, map adequacy, and relation of detailed regulations to local physical and social conditions. As a result, the Federal Insurance Administration found itself locked into sometimes unwieldy or ineffective procedures that might well have been avoided in the light of experimentation. The attempt in the late 1970s to set up a nation-wide floodplain map file was likewise an unfortunately hasty enterprise. In its 23 years of operations, the National Flood Insurance Program has achieved much and continues to gain new experience. The current implementation of the Community Rating System now offers special opportunities to appraise the suitability of national standards and procedures at the local level. As new improvements are made in Federal programs, it would be important to craft them on an experimental basis with careful provision for evaluation as they are launched.

A second lesson derives from the contrast over the years between expressions of desirable unified policy and measures to, in practice, unify the activities of agencies which in theory subscribe to the policy. There has been neither a single statement of Congressional intent with respect to floodplain management such as in the Earthquake Hazards Reduction Act of 1977, nor a delegation to a single executive agency of responsibility for coordination of the various Federal programs. The Bureau of the Budget was interested in such coordination in the mid 1960s but did not take a strong hand. The Water Resources Council served as a meeting place of interested agencies without having statutory authority. After the Council disbanded in 1982 it was followed by the Interagency Task Force, a voluntary group that also lacked authority to enforce desirable action as outlined in three Executive Orders. It cannot be expected that conscientious administrators will abandon their own statutory authority and responsibility before joining cooperative ventures, no matter how desirable the goals. It is just as clear that unless a strong statement is made by the Congress on the ways in which the basic policies of the individual Federal agencies are to be related to the underlying aims in managing floodplain resources those policies will have little significance in the field where they influence or are constrained by State and local practices.

The third major lesson is that floodplain policy changes must be taken in the context of broad environmental goals applied to local conditions. This was the case in the unfolding of the Coastal Zone Management Act where four Federal agencies have joined in a partnership for action on habitat protection, nonpoint source pollution management, and sediment control. It occurs in the implementation of soil conservation programs on lands where environmental integrity must harmonize with economic considerations. It is acutely the case in the delineation of wetlands where the rigidity of proposed national criteria confronts wide variety in interpretation of suitable floodplain use. Coastal erosion raises similar issues. The reconciliation of multiple and sometimes inconsistent national goals is an endemic problem in resource management. It can only be achieved effectively by dealing with particular landscapes in particular regions. When national goals shift or are clarified, as they surely will, the complexity increases. Unless floodplain management practices take into account local food and fiber production, biota, water supply, urban land use, recreation, and more - in addition to flood loss reduction - the goals for maintaining the sustainability of floodplains will surely not be met.

Experience over the past 25 years suggests that to help achieve the improvements in prospect will require a willingness to test and appraise new programs, a Congressional definition of unified Federal policy, an executive decision to assure the coordination of the Federal agencies, and a commitment by representatives of the principal State, local, and nongovernment groups to collaborate in adapting national aims to local conditions where the benefits will be seen - on the borders of the nation's rivers, lakes, and coasts. Without these measures, the resources of those areas will remain unduly vulnerable to natural extremes in stream flows and tides and the people of this nation will receive less than optimal benefits from floodplains' products of amenities, soil, water, and biota.

08 Oct 1991

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PART VII:

APPENDICES

❑ **APPENDIX A:**
CHRONOLOGY OF SIGNIFICANT ACTIVITIES AND EVENTS INFLUENCING DEVELOPMENT OF THE NATION'S PROGRAM FOR FLOODPLAIN MANAGEMENT

❑ **APPENDIX B:**
LIST OF ACRONYMS AND ABBREVIATIONS

❑ **APPENDIX C:**
GLOSSARY

❑ **APPENDIX D:**
SELECTED REFERENCES

❑ **APPENDIX E:**
AGENCIES AND ORGANIZATIONS INVITED TO COMMENT ON THE *STATUS REPORT* AND ON THE EFFECTIVENESS OF FLOODPLAIN MANAGEMENT

❑ **APPENDIX F:**
"ACTION AGENDA FOR MANAGING THE NATION'S FLOODPLAINS"

APPENDIX A:

CHRONOLOGY OF SIGNIFICANT ACTIVITIES AND EVENTS INFLUENCING DEVELOPMENT OF THE NATION'S PROGRAM FOR FLOODPLAIN MANAGEMENT

MAJOR FEDERAL ACTIONS[1]

1849-50 — Swamp and Overflow Land Acts of 1849 and 1850. Congress deeded millions of acres of swampland to states along the Mississippi River. States sold land to pay for construction of flood control levees. New private owners drained swampland, converted it to agricultural use, and demanded protection by new and larger levees.

1879 — Congress created the Mississippi River Commission. Gave control to the Corps of Engineers (Corps) and directed the Corps to "prevent destructive floods."

1889 — First stream-gaging station in the United States set up on the Rio Grande at Embudo, NM.

1890 — River and Harbor Act of 1890. Gave the Corps responsibilities for regulating structures in navigable waters.

1899 — River and Harbor Act of 1899. Gave Corps responsibilities for regulating pollutants in Nation's waterways (Refuse Act).

1902 — Federal Reclamation Act of 1902. Established what is now the Bureau of Reclamation.

1903 — Flood studies became part of the U.S. Geological Survey (USGS) water resources program following disastrous floods in the Passaic River basin in northern New Jersey in 1902 and 1903.

1905 — Act of Congress (33 Stat. 599), chartered the American National Red Cross to undertake disaster relief activities.

1917 — The Flood Control Act of 1917 (P.L. 64-367; 33 Stat. 701-3). The beginning of federally sponsored flood control, with projects on the Mississippi and Sacramento Rivers.

— U.S. Department of Agriculture (USDA) began experimental rainfall and runoff measurements that provided the basic concepts and data for development of the rational method for computing maximum runoff.

1920 — Federal Power Act (P.L. 66-280). The Act established the Federal Power Commission (FPC) to license nonfederal hydroelectric projects. The Act requires that all of the Commission's licensed projects must be safe, adequate, and best adapted to a comprehensive basin plan of the river.

1928 — The Flood Control Act of 1928.

— Initiation of Mississippi River and Tributaries Project, Corps of Engineers.

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1 Many of these activities were performed in cooperation with, or resulted from, prior actions of state and local governments.

— Congress limited the federal financial contribution for cooperative water resources studies to no more than 50% of the funds for each investigation.

1933 — TVA Act of 1933 (Public 17, 73d Cong. 48 Stat. 58). Established the Tennessee Valley Authority (TVA).

— The United States-Mexico Convention of February 1, 1933 (TS 864; 48 Stat. 1621) provides for international boundary stabilization and flood control along a 90-mile reach of the boundary section of the Rio Grande.

1934 — Report of Water Resources Committee of National Resources Board.

1935 — Soil Conservation Act of 1935 (P.L. 74-46; 49 Stat. 163). Directed the Secretary of Agriculture to establish the Soil Conservation Service (SCS).

1936 — The Flood Control Act of 1936 (P.L. 74-738; 49 Stat. 1570). Expanded federal responsibility for flood protection projects to all navigable rivers, and authorized the SCS to undertake studies and investigations of watersheds of all waterways covered by Corps "308" reports.

1937 — Federal Aid in Wildlife Restoration Act of 1937 (50 Stat. 917). Authorized grants and technical assistance for land acquisition, development, research, and coordination for wildlife management or restoration.

1938 — The Flood Control Act of 1938. Authorized permanent evacuation of flood areas in lieu of flood protection.

1944 — Flood Control Act of 1944 (P.L. 78-534; 58 Stat. 887, 905). Authorized USDA to implement reports completed under authority of P.L. 74-738.

— The United States-Mexico Water Treaty of February 3, 1944 (TIAS 994; 59 Stat. 1219). Provides the basis for international flood control projects along the boundary sections of the Colorado River and the Rio Grande.

1950 — Federal Disaster Act (P.L. 81-875). First comprehensive disaster relief act.

— Federal Civil Defense Act of 1950 (P.L. 81-920). Authorized federal assistance to state and local emergency management agencies.

— Report of President Truman's Commission on Water Resources Policy, including recommendations that federal authorities consider floodplain zoning and flood forecasting as integral parts of flood management.

— Federal Aid in Sport Fish Restoration Act of 1950 (64 Stat. 430). Authorized grants to restore and manage sport fisheries.

1951 — *Principles of a Sound National Water Policy*. Report issued by the Engineers Joint Council recommended emphasis on "sustained land utility" rather than flow retardation.

1953 — Establishment of disaster relief programs under the Small Business Administration.

— Initiation of first full-scale regional floodplain management program by the TVA.

1954 — The Watershed Protection and Flood Prevention Act of 1954 (P.L. 83-566; 68 Stat. 666). Authorized SCS to help local organizations plan and carry out works of improvement for flood prevention and conservation on watersheds that did not exceed 250,000 acres in size.

1958 — Fish and Wildlife Coordination Act (P.L. 85-624; 72 Stat. 507, 563).

1959 — TVA transmitted to Congress a study and report entitled *A Program for Reducing the National Flood Damage Potential*, based on its local floodplain management assistance experiences.

1960 — Flood Control Act of 1960 (P.L. 86-645). Section 206 authorized the Corps of Engineers to establish a National Program for Flood Plain Management Services.

1961 — The Housing Act of 1961. Authorized federal grants to communities for acquisition of open space for conservation, recreation, and related purposes.

1962 — Senate Document 97, *Policies, Standards, and Procedures in the Formulation, Evaluation, and Review of Plans for Use and Development of Water and Related Land Resources*. Forerunner of the "Principles and Standards."

1963 — United States-Mexico Convention of August 29, 1963 (TIAS 5515; 15 UST 21) provides for boundary stabilization and flood control along 4.4 miles of the Rio Grande boundary river.

1964 — Water Resources Research Act of 1964 (P.L. 88-379). Authorized establishment of state water resources research institutes.

— The Land and Water Conservation Fund Act (P.L. 88-578; 78 Stat. 897). Authorized funds to purchase federal land and water resources and to help state and local governments buy and develop recreation areas.

1965 — Southeast Hurricane Disaster Relief Act of 1965 (P.L. 89-339). Authorized feasibility study of a national flood insurance program.

— Water Resources Planning Act of 1965 (P.L. 89-80; 79 Stat. 244). Created the U.S. Water Resources Council (WRC); authorized creation of federal-state river basin commissions; required establishment of principles, standards, and procedures to be followed for all federal projects affecting water and related land areas.

1966 — House Document 465. *A Unified National Program for Managing Flood Losses*.

— E.O. 11296, "Evaluation of Flood Hazard in Locating Federally Owned or Financed Buildings, Roads, and Other Facilities, and in Disposing of Federal Lands and Properties." The first floodplain Executive Order.

— National Historic Preservation Act (P.L. 89-665; 80 Stat. 915). The basic federal statute regarding historic preservation; ensures that no federal funds are spent on work affecting historic properties until local groups and the National Advisory Council on Historic Preservation have a chance to review the project plan.

1967 — *A Uniform Technique for Determining Flood Flow Frequencies* (Bulletin No. 15, issued by WRC Hydrology Committee).

— *Introduction to Flood Proofing* (Corps/TVA publication distributed nationally).

— *Guidelines for Reducing Flood Damages* (Corps pamphlet distributed nationally).

— *List of Urban Places with Information About Flood Problems* (Corps National Inventory).

1968 — National Flood Insurance Act of 1968 (P.L. 90-448). Authorized establishment of a National Flood Insurance Program (NFIP) within the Department of Housing and Urban Development (HUD).

— *The Nation's Water Resources* (first national water assessment published by WRC).

— Formula for determining the discount rate for water projects modified by WRC.

— Wild and Scenic Rivers Act of 1968 (P.L. 90-542). Ensures that no federal agency recommends authorization of any water resources project that would have a direct and adverse effect on the values of rivers designated "wild and scenic."

— P.L. 90-515 authorized establishment of a National Water Commission.

1969 — *Proposed Flood Hazard Evaluation Guidelines for Federal Agencies* released by WRC for review and testing.

— Housing and Urban Development Act of 1969 (P.L. 91-152; 82 Stat. 587), established the emergency phase of the NFIP.

1970 — The National Environmental Policy Act of 1969 (P.L. 91-190). Created the Council on Environmental Quality and established requirements for environmental impact assessments of federal actions.

— President's Water Policy Message.

— Establishment of the Environmental Protection Agency, under Reorganization Plan No. 3 of 1970.

— The Water Bank Act (P.L. 91-559; 84 Stat. 1468).

— Environmental Quality Improvement Act of 1970 (P.L. 91-224). Requires federal agencies to implement environmental policy.

— Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (P.L. 91-646). Ensures uniform and equitable treatment of persons displaced by federally assisted programs.

— United States-Mexico Boundary Treaty of November 23, 1970 (TIAS 73; 23 UST) provides for boundary river stabilization and international management of the boundary river floodplains for the 1254-mile international reach of the Rio Grande and the 24 miles international reach of the Colorado.

1971 — *Regulation of Flood Hazard Areas to Reduce Flood Losses* (Volumes 1 and 2) published by WRC.

1972 — National Dam Inspection Act (P.L. 92-367).

— Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500; 86 Stat. 816). Required a permit from Corps for placing dredge and fill material into, or adjacent to, waters of the U.S.; development of water quality management plans by each state; permits required for municipal and industrial discharges.

— Coastal Zone Management Act (P.L. 92-583). Authorized development of state coastal management plans and required that actions of federal agencies be consistent with approved plans.

— *Flood Hazard Evaluation Guidelines for Federal Executive Agencies* issued by WRC for compliance with E.O. 11296.

— *Flood Plain Regulations*, distributed nationally by the Corps to guide state and local flood hazard statutes.

1973 — The Flood Disaster Protection Act of 1973 (P.L. 93-234; 87 Stat. 979). Included incentives for participation in the NFIP and sanctions for nonparticipation.

— The "Principles and Standards for Planning of Water and Related Land Resources" ("Principles and Standards") adopted by WRC.

— Endangered Species Act of 1973 (P.L. 93-205; 87 Stat. 884). Requires federal agencies to ensure that their projects do not jeopardize endangered or threatened species of plants and wildlife or their habitat.

1974 — Water Resources Development Act of 1974 (P.L. 93-251; 88 Stat. 12, 32). Sec. 73 encouraged consideration of nonstructural approaches in federal water resource projects; Sec. 80(c) required an investigation and study of principles and standards for planning and evaluation of water and related resource projects.

— Disaster Relief Act of 1974 (P.L. 93-288). Required applicants for disaster assistance to take actions to mitigate hazards as a condition of receiving disaster assistance and that rebuilding be done in conformance with applicable codes, specifications and standards.

— Archaeological and Historic Preservation Act of 1974 (P.L. 93-291). Ensures preservation of historical and archeological materials.

1975 — Interagency Task Force on Floodplain Management created (formerly a committee).

1976 — *A Unified National Program for Flood Plain Management* published by WRC.

1977 — E.O. 11988, Floodplain Management (superseded E.O. 11296).

— E.O. 11990, Protection of Wetlands.

— The Housing and Community Development Act of 1977 (P.L. 95-128), including significant amendments to the NFIP.

— President Carter directed federal agencies to review their dam safety practices.

— Soil and Water Resources Conservation Act of 1977 (P.L. 95-192). Required SCS to develop a National Conservation Program.

— Clean Water Act of 1977 (P.L. 95-217).

— The Federal Power Commission (FPC) became the Federal Energy Regulatory Commission (FERC) when the Department of Energy Organization Act (P.L. 95-91) was enacted. Most FPC duties were transferred to the FERC.

1978 — *The Second National Water Assessment: The Nations' Water Resources 1975-2000*, published by WRC, which included Appendix B, "Estimated Flood Damages, Nationwide Analysis Report."

— *Floodplain Management Guidelines for Implementing E.O. 11988* released by WRC.

— President's Water Policy Message: Required consideration of nonstructural measures in all flood control feasibility studies.

— National Water-use Information Program established within USGS to collect, store and disseminate water-use information.

1979 — E.O. 12127. Established the Federal Emergency Management Agency.

— Revisions to the "Principles and Standards."

— FEMA's State Assistance Program initiated.

— *A Unified National Program for Flood Plain Management* (updated from 1976 version).

1980 — Sec. 406 of P.L. 93-288 put into effect. Disaster assistance contingent on hazard mitigation planning.

— OMB memorandum issued on "Nonstructural Flood Protection Measures and Flood Disaster Recovery."

— "Interagency Agreement for Nonstructural Damage Reduction Measures as Applied to Common Flood Disaster Planning and Post-Flood Recovery Practices" signed in December by 12 federal agencies in response to OMB memorandum.

— First properties acquired under FEMA's Flooded Property Program (Section 1362 of NFIA).

— Amendments (P.L. 96-515) to the National Historic Preservation Act. Directed federal agencies to establish historic preservation programs.

1981 — Omnibus Budget Reconciliation Act (P.L. 97-35). Prohibited issuance of federal flood insurance after 10/10/83 for new construction or substantial improvements in designated areas of undeveloped coastal barriers.

— Establishment of Interagency Hazard Mitigation Teams in accordance with the "Interagency Agreement for Nonstructural Damage Reduction Measures."

— Federal Insurance Administration (FIA) established the Write Your Own program to involve private insurance companies in the NFIP.

1982 — Coastal Barrier Resources Act (P.L. 97-348). Created Coastal Barrier Resources System and limited use of federal funds (including flood insurance) in designated areas of undeveloped coastal barriers.

— Volume 3 of *Regulation of Flood Hazard Areas to Reduce Flood Losses* published by WRC.

— WRC's staff disbanded and its functions transferred to other federal agencies or assumed by the President's Cabinet on Natural Resources.

— FEMA becomes chairman of the Interagency Task Force on Floodplain Management.

— Corps report on *National Program of Inspection of Non-Federal Dams.*

1983 — Initiation of Integrated Emergency Management System (IEMS) by FEMA.

— *Economic and Environmental Principles and Guidelines for Water and Related Land Resources for Implementation Studies* issued to replace the "Principles and Standards."

— National Hurricane Center began to include the probability of a hurricane reaching landfall at specific locations in Public Advisories.

1985 — The Food Security Act of 1985 (P.L. 99-198), including "Swampbuster" provisions.

1986 — *A Unified National Program for Floodplain Management*, updated from 1979 version.

— Water Resources Development Act of 1986 (P.L. 99-662). Section 402 requires nonfederal interests to participate in and comply with the NFIP before construction of any federally financed local flood protection project; broadened cost sharing for water resources projects.

— The Tax Reform Act of 1986. Limited deductions for casualty losses and reduced tax incentives for development.

— Emergency Wetlands Resources Act of 1986. Provided funds for acquisition of wetlands.

1987 — Bureau of Reclamation reorganization announced.

— Housing and Community Development Act of 1987 (P.L. 100-242). Section 544 (Jones/Upton Amendment) authorizes prepayment of flood insurance for structures in imminent danger of collapse due to coastal erosion.

— Water Quality Act of 1987 (P.L. 100-4; 101 Stat. 7). Section 317 established the National Estuary Program; Section 405 provided for control of municipal and industrial stormwater discharges.

1988 — Disaster Relief and Emergency Assistance Amendments of 1988 (P.L. 100-707). Provides for use of disaster assistance funds after a Presidential disaster declaration for a 50/50 cost sharing for mitigation actions.

— Congress passed a resolution endorsing the U.S. Decade for Natural Disaster Reduction.

1989 — U.S. National Committee for the Decade for Natural Disaster Reduction established at the request of the federal interagency Subcommittee on Natural Disaster Reduction.

SELECTED STATE AND LOCAL ACTIONS[2]

1929 — New Jersey adopted channel encroachment regulations.

1935-6 — Washington adopted one of the first state floodway regulatory programs, followed by a broader Flood Control Zone Act that authorized state identification and regulation of flood hazard zones.

1949 — Iowa started providing planning assistance for flood damage reduction and required state approval of flood control works. State law made it illegal to undertake certain activities in floodplains (no penalties or enforcement mechanism).

1955 — Connecticut adopted stream channel encroachment lines.

1957 — Iowa developed state law requiring a mandatory permit system for construction within floodways of streams.

1960 — Maryville and Alcoa, Tennessee. Joint flood damage reduction planning and community redevelopment.

1963 — Massachusetts adopted first state permit system for coastal wetlands.

1965 — Iowa extended its mandatory permit system to the entire floodplain.

1966 — Wisconsin Water Resources Act, mandating local regulation of flood hazard and shoreline areas consistent with state standards.

1967 — Maryland adopted regulations for the 50-year floodplain as part of its state water pollution control program.

1969 — Minnesota adopted a state floodplain management program in conjunction with a shoreland zoning program.

1975 — Baltimore County, MD. Initiation of comprehensive flood hazard management program relying on county funds.

— Scottsdale, AZ. Acquisition of floodway corridor for recreation.

1976 — Soldiers Grove, WI. Development of plan combining flood reduction and community revitalization (not implemented until after floods of July 1978).

1977 — Clinchport, VA. Floodplain evacuation/relocation following devastating floods in April 1977 (based on study done in 1972).

[2] Many of these activities were performed in cooperation with federal agencies.

1978 — Massachusetts established a Coastal Floodproofing Program to provide technical and financial assistance to homeowners whose property was damaged during the "Blizzard of '78."

— Lee County, FL. Nation's first regional comprehensive hurricane evacuation study prepared.

1979 — Minnesota enacted a Wetlands Tax Exemption and Tax Credit Program designed to provide incentives for preserving wetlands.

1980 — Littleton, CO. Acquired overflow areas and converted to park land.

1982 — Kentucky established a Community Flood Damage Abatement Program to provide financial assistance to communities for several types of flood control projects.

1983 — Charles River, MA. Acquired natural flood storage area upstream of communities.

— Maine enacted "Rule 80K" allowing code enforcement officials to take code violations to court.

— Colorado published the *Colorado Flood Proofing Manual.*

— Illinois published the first in a series of manuals directed to assisting homeowners deal with flooding problems.

— Florida created the Kissimmee River-Lake Okeechobee-Everglades Coordinating Council to restore wetlands along the Kissimmee River, including oxbows and floodplain marshes destroyed as part of an earlier flood control project.

1985 — Prairie du Chien, WI. Converted evacuated flood-prone areas to open space greenbelt.

1987 — Washington enacted legislation prohibiting new residences in the floodway and giving the Department of Ecology authority to set additional requirements and to review and approve local ordinances.

— Minnesota created a program for flood damage reduction assistance that provides matching funds for a variety of community actions, including relocation of floodplain structures.

— Des Plaines, IL initiated a permit surcharge of $200 for floodplain development projects to help finance city flood protection activities.

1988 — Illinois developed a low interest floodproofing loan program to enable low to moderate income victims of a 1987 flood to protect themselves from repeated damages of future flooding.

— California legislated mapping of landslide hazards by the State Geologist.

— Utah State Legislature appropriated funds for state-wide mapping of debris-flow hazards.

— North Carolina policy to allow natural forces to act on the shoreline.

— First ALERT system in California.

— Pennsylvania created a $100,000 loan program to encourage industrial floodproofing.

— Howard County, Maryland established a floodproofing loan program for local residents and commercial establishments using a combination of state and local funds.

— California enacted law on dam safety.

— Town of Nags Head, NC developed a postflood recovery plan and adopted policies and implementing actions "to reduce, to the extent possible, future damage from hurricanes and severe coastal storms."

— North Carolina policy/plan required local plans to include a poststorm policy section.

SELECTED PRIVATE ACTIONS

1905 — American National Red Cross chartered by Congress as a national disaster relief agency.

1913 — Establishment of Miami Conservancy District of the Ohio Valley.

1945 — Publication of *Human Adjustment to the Flood Problem in the United States* by Dr. Gilbert White.

1953 — Establishment of The Nature Conservancy.

1962 — Publication of *Guide for the Development of Flood Plain Regulations* by the American Society of Civil Engineers.

1965 — Charles River Watershed Association founded; advocacy of structural/nonstructural flood management program.

1976 — Natural Hazards Research and Applications Information Center established at the University of Colorado, Boulder, CO.

1977 — Formation of Association of State Floodplain Managers.

1980 — Formation of Association of State Wetland Managers.

1982 — Arizona Floodplain Management Association formed, the first of its kind in the country and the first state chapter to be accepted into the ASFPM.

1984 — Formation of Association of State Dam Safety Officials.

SELECTED MAJOR FLOOD EVENTS

1889 — Johnstown, Pennsylvania: Dam break killed 2,200 people.

1900 — Hurricane at Galveston, Texas killed approximately 6,000 people.

1913 — Ohio River Valley floods. 713 people killed in Ohio and Indiana.

1926 — Miami, Florida. Hurricane killed more than 100 people.

1927 — Lower Mississippi River flooding killed between 250 and 500 people.

1928 — Santa Clara Valley, California. St. Francis Dam failed and flooding killed 420 people.

1928 — Hurricane. Killed 1,000 people in Puerto Rico, 2,000 people in Florida.
— Lake Okeechobee dikes failed.

1935 — Lower Matecumbe Key, Florida. Hurricane killed 400 people.

1935-8 — Series of severe droughts and major floods affecting large portions of the country, including 1936 floods on the Potomac, Susquehanna, and upper Ohio River Basins; 1937 floods in the Ohio Valley; and 1938 Atlantic Seaboard hurricane killed almost 700 people.

1938 — California. Sacramento-San Joaquin River delta flooding killed at least 16 people.
— Los Angeles-Southern California. Floods and landslides killed 95 people.
— Alabama and Georgia. A tornado and floods that followed killed 27 people.

1939 — Northeastern Kentucky flash floods killed at least 75 people.
— Southern California Coast. A tropical storm killed 18 people.

1940 — New York and Pennsylvania. Floods killed 17 people.
— Southern Texas. The Lavaca, Colorado, and Guadalupe rivers flooded after heavy rainstorms and killed at least 10 people.
— Texas and Louisiana. Flooding in the Sabine River region after a hurricane killed 19 people.
— Eastern United States. Flooding after a hurricane from Savannah, Georgia to Georgetown, South Carolina killed at least 16 people.

1941 — Midwestern United States. Severe storms in Minnesota and South Dakota killed approximately 150 people.

1942 — Eastern Pennsylvania. Flooding killed at least 30 people.

1943 — West Virginia. Flash flood killed 21 people.

1944 — East Coast, United States. A hurricane between the Carolinas and Canada killed at least 35 people.

1945 — Cincinnati, Ohio. Flooding on the Ohio River and other midwestern rivers in Pennsylvania, West Virginia, Kentucky and Indiana killed at least 10 people.

1946 — Hawaiian Islands. Series of Tsunamis killed 159 people.
— Susquehanna River Valley, New York-Pennsylvania. Flooding killed 12 people.

1947 — Cambridge, Nebraska. Flash flood killed 16 people.
— St. Louis Missouri. Flooding in the Missouri and upper Mississippi valleys killed 16 people.
— Gulf of Mexico. A hurricane hitting southern Florida,, Louisiana and Mississippi killed 84 people.
— New Orleans, Louisiana. Flooding after a hurricane at least 55 people.

1948 — Columbia River Basin, Oregon. Flooding killed 40 people; large economic losses; failure of Columbia River dike killed 15 people.

1950 — West Virginia. Flash floods killed 33 people.

1951 — Major flooding on the Kansas and lower Missouri Rivers killed 28 people and resulted in huge economic losses.

1953 — Louisiana. Floods in the wake of tornadoes killed 12 people.

1954 — Hurricane Hazel. Major flooding in southern New England killed 99 people.
— Hurricane Edna. Struck from Cape Hatteras, North Carolina to Nova Scotia and killed at least 22 people.
— Chicago, Illinois. A severe rainstorm killed 19 people.

1955 — Hurricane Diane. Major flooding in southern New England Pennsylvania and New York killed 200 people.
— Northeastern United States. Torrential rains and floods killed 42 people.
— Northern California-Oregon. Flooding killed 80 people.
— Yuba City, California. Dike failures and flooding along the Yuba River killed 80 people. Successful evacuation limited deaths.

1956 — Pennsylvania. Flooding killed 15 people.
— Hurricane Flossey. Struck Florida, Georgia and Louisiana and killed at least 24 people.

1957 — Hurricane Audrey. Cameron Parish, Louisiana hit by tidal wave and several hundred people killed.
— Kentucky, Virginia and West Virginia. Flooding in the Cumberland Valley killed 15 people.
— St. Louis Missouri. Flash flooding killed 17 people.

1958 — Lituya Bay, southeast Alaska. Tsunami killed 2 people.
— Northern California. Flooding killed 13 people.
— Audubon, Iowa. Rainstorm killed 13 people. 6 missing and presumed dead.
— North Central Indiana. Flooding killed 13 people.

1960 — Tsunami killed 61 people in Hawaii, mostly in Hilo.

1961 — Hurricane Carla. Struck Texas-Louisiana and only 40 people were killed due to an orderly evacuation.
— Charleston, West Virginia. Flash flooding killed 21 people.
— Georgia, Alabama, Mississippi and Louisiana. Flooding killed 12 people.

1962 — Good Friday northeaster affected eastern seaboard from SC to CT.
— Southern California. Flooding and mud slides killed 20 people.

— East Coast, United States. Heavy storm with racing tides killed at least 40 people. March 10.
— Pacific Northwest, United States. A severe storm from the ocean with high winds killed at least 46 people.
— Guam. Typhoon Karen killed 6 people. Early warnings allowed an orderly evacuation.

1963 — Los Angeles, California. Baldwin Hills dam failure. Successful evacuation limited deaths to 5 people.
— Eastern United States. Flooding in 10 Atlantic seaboard and Ohio Valley states killed 21 people.

1964 — "Good Friday" earthquake generated tsunami that killed 131 people in Alaska, Oregon and California.
— Dam at Swift, Montana failed, killing 19 people.
— Midwestern United States. Flooding in the Ohio River Valley states of Pennsylvania, Ohio, West Virginia, Kentucky and Indiana killed 15 people.
— Montana. Flash flooding killed 34 people, broke dams and washed out bridges. 30 people missing.
— Pacific Northwest. Washington, Oregon and northern California. Flooding rivers killed at least 42 people.

1965 — Hurricane Betsy struck southern Florida and the Mississippi River delta and killed 74 people.
— Mississippi Valley, United States. The month-long rampage of the Mississippi River, from St. Paul-Minneapolis to St. Louis, was recorded as the greatest flood in the river's history and killed 15 people.
— Sanderson, Texas. Flash flood killed 16 people.
— West Central United States. Rainstorms in Montana set off flooding in the Arkansas and South Platte river valleys through Wyoming, Colorado, Nebraska, Kansas and New Mexico which killed 20.

1969 — Hurricane Camille. The states of Mississippi, Louisiana, Alabama, and Virginia were ravaged and at least 400 people were killed or presumed dead.
— Southern California. Torrential rains and mud killed at least 100 people.
— Southern California. Renewed flooding and mudslides killed at least 18 people.
— Ohio. A sudden violent storm caused high choppy waters on Lake Erie and flooding. 41 people were killed.

1970 — Hurricane Celia killed 14 people in Florida and 13 people in Texas.
— Arizona. Flooding in Maricopa County killed 15 people.
— Puerto Rico. A tropical depression and associated heavy rainfall killed at least 60 people.

1971 — Baltimore County, Maryland. Heavy Rains and swollen rivers killed 13 people.
— Pennsylvania. Flooding left 13 people dead or missing.

1972 — Flash floods and dam failure in Black Hills of South Dakota killed 236 people.
— Coal waste dam failed on Buffalo Creek, West Virginia, killing 125 people.
— Tropical Storm Agnes, Eastern seaboard killed 117 people.

1973 — Mississippi River Basin flooding.
— Lake Michigan. A 24-hour storm churned up Lake Michigan causing damage to 28 miles of lakefront. The storm killed 26 people.

1975 — Hurricane Eloise struck Puerto Rico and dumped torrential rains that killed 34 people. The storm moved to the Florida panhandle and killed 12 people before continuing to eastern Alabama.

1976 — Teton Dam at Teton, Idaho failed, killing 11 people.
— Big Thompson Canyon, Colorado flash flood killed 139 people.

1977 — Flash flood and dam failures near Johnstown, Pennsylvania caused 78 deaths.
— Flash floods in Kansas City, Missouri and adjacent areas killed 25 people.
— Kelly Barnes Dam, Georgia, failed killing 39 people.

1979 — Hurricane Frederick, Gulf Shores, Alabama.

— Lake flooding at Lake Elsinore, CA.
— Great Salt Lake began to increase in size.
— Great Lakes rise.
— Pearl River flooding, Mississippi.

1980 — Eruption of Mount St. Helens, causing floods and mudflows on the North Fork Toutle River, Cowletz River and Columbia River.
— Southern California and Arizona. Flooding killed 26 people.

1982 — Connecticut. Flooding killed 12 people.

1983 — Alabama, Mississippi, Louisiana and Tennessee. Flooding killed 15 people.
— Hurricane Alicia struck southern Texas and killed 17 people.

1984 — Vermont. Flash flood caused by collapse of series of beaver dams washed out railroad track support. Subsequent derailment of Amtrak Montrealer killed 5 people.

1985 — Hurricane Gloria. Severe flooding along Lackawanna River in Pennsylvania.

1986 — Allegheny County, Pennsylvania. Flooding killed 8 people.
— South Dakota. Severe storms and flooding.

1987 — Typhoon Nina struck the island of Truk, Federated States of Micronesia and killed 5 people.
— Maine, Massachusetts and New Hampshire. Severe spring flooding.
— Typhoon Lynn struck the Northern Mariana Islands causing significant damage to public property and no deaths.

1988 — Typhoon Roy struck Guam, Marshall Islands and the Island of Rota, Northern Marianas with no deaths.

1989 — Utah. Dike failure at Quail Creek Reservoir caused flash floods.
— Kentucky. Heavy rains and flooding in central and western Kentucky effected 18 counties.
— Washington. Mudslides and flooding.
— Alaska. Flooding on the Yukon and Kuskokwim Rivers and their tributaries.
— Hurricane Hugo. Severe damage in U.S. Virgin Islands, Puerto Rico and South Carolina. Estimated more than $10 billion in damages.

SIGNIFICANT FLOODPLAIN REGULATORY CASES[3]

1930 — *America Land Co. v. City of Keene*, 41 F. 2d 484 (1st Cir., 1930). Court upheld a zoning ordinance that prevented residential development in a riverine flood hazard area.

1953 — *McCarthy v. Manhattan Beach*, 257 P. 2d 679 (Cal., 1953). Court upheld a coastal beach zone that prevented all but beach recreational uses in an area subject to storm damage.

[3] This annotated list of 48 of the most significant court cases dealing with floodplain regulations was selected from a broader group of approximately 270 constitutionally-related floodplain regulatory cases. Selection was based upon the level of decision (e.g., State Supreme Court versus lower court, the issues considered by the case, and the quality of the legal analysis). The list includes cases that uphold and strike down regulations. It should be noted that virtually all of the cases that hold regulations to be unconstitutional are older cases.

1957 — *Ardolino v. Board of Adjustment of Borough of Florham Park*, 130 A. 2d 847 (N.J., 1957) Court strongly endorsed power of planning commission to impose conditions upon plat approval relating to drainage and flooding.

1959 — *Vartelas v. Water Resources Comm'n*, 153 A. 2d 822 (Conn., 1959). Court upheld a Connecticut, state-level, encroachment statute.

1960 — *Longridge Estates v. City of Los Angeles*, 6 Cal. Rptr. 900 (Cal., 1960). Court held that city could reasonably charge subdivider $9,944 for connection to use of municipal storm drains and sewers where fees went exclusively for the construction of outlet sewers.

1960 — *City of Buena Park v. Boyar*, 8 Cal Rptr. 674 (Cal., 1960). Court upheld condition that $50,000 be paid by developers to permit municipal construction of a drainage ditch to carry away surface waters from subdivision plat approval.

1962 — *Consolidated Rock Products Co. v. Los Angeles*, 370 P. 2d 342 (Cal., 1962), appeal dismissed, 371 U.S. 36 (1962). Court upheld an ordinance that prevented gravel operations in an area which, due to flooding, had few, if any, other economic uses.

1963 — *Morris County Land Imp. Co. v. Parsippany-Troy Hills Tp.*, 193 A. 2d 232 (N.J., 1963). Court invalidated a conservancy district designed to preserve wildlife and headwater storage areas.

1964 — *Dooley v. Town Plan & Zoning Comm'n. of Town of Fairfield*, 197 A. 2d 770 (Conn., 1964). Court invalidated a floodplain zoning ordinance for estuarine area as applied to a plaintiff's land.

1965 — *Blakeman v. Planning Commission of City of Shelton*, 206 A. 2d 425 (Conn., 1965). Planning commission could refuse plat approval for subdivision of 34 acres where there was evidence that proposed street access would cause surface drainage problems.

1966 — *Spiegle v. Beach Haven*, 218 A. 2d 129 (N.J., 1966). Court upheld building setback and fence ordinances for coastal areas.

1967 — *Baker v. Planning Board of Framingham*, 228 N.E. 2d 831 (Mass., 1967). Court invalidated a refusal of a planning commission to approve a subdivision plat for a parcel of land that functioned as a natural flood storage area.

1968 — *Iowa Natural Resources Council v. Van Zee*, 158 N.W. 2d 111 (Ia., 1968). Court generally upheld an Iowa, state-level, encroachment statute.

1969 — *Brown v. City of Joliet*, 247 N.E. 2d 47 (Ill., 1969). City council could refuse plat approval where no provision was made in subdivision plan for drainage as required by statute.

1972 — *Turner v. County of Del Norte*, 101 Cal. Rptr. 93 (Cal., 1972). Court upheld county floodplain regulations limiting an area subject to severe flooding to parks, recreation and agricultural uses.

— *Turnpike Realty Co. v. Town of Dedham*, 284 N.E. 2d 891 (Mass., 1972), cert. denied, 409 U.S. 1108 (Mass., 1973). Court upheld zoning regulations essentially limiting the floodplain to open space uses despite testimony that the land was worth $431,000 before regulations and $53,000 after regulations and evidence that several hills above the regulatory flood elevation had been included in the floodplain district.

1973 — *Cappture Realty Corp. v. Board of Adjustment of Borough of Elmwood Park*, 313 A. 2d 624 (N.J., 1973). Court upheld interim zoning ordinance declaring a moratorium on construction in flood-prone area unless special exception permits were obtained.

1974 — *A.H. Smith Sand and Gravel Co. v. Dept. of Water Resources*, 313 A. 2d 820 (Md. 1974). Court upheld an order of the Maryland Department of Natural Resources prohibiting filling on land within the 50-year floodplain but redefined floodplain boundaries in light of new flood information.

1976 — *Lindquist v. Omaha Realty, Inc.*, 247 N.W. 2d 684 (S.D., 1976). Court held that resolution of the Rapid City City Council prohibiting the issuance of building permits for one block on either side of Rapid Creek after the devastating flood of June 12, 1972, until a study was completed by the planning commission, was a valid exercise of the police power.

1977 — *Maple Leaf Investors, Inc. v. State Dept. of Ecology*, 565 P. 2d 1162 (Wash., 1977). Court upheld denial of a state permit for proposed houses in floodway of the Cedar River and held that both the statute and regulations adopted pursuant to them were valid.

— *Pope v. City of Atlanta*, 240 S.E. 2d 241 (Ga., 1977). Court held that the Georgia River Protection Act, designed in part to address flooding and erosion problems, served valid objectives and did not violate home rule.

1978 — *Texas Landowners Rights Ass'n. v. Harris*, 453 F. Supp. 1025 (D. D.C., 1978, aff'd mem. 598 F. 2d 311 (D.C. Cir., 1979) cert. denied 444 U.S. 927 (1979). Court held that the National Flood Insurance Program and its requirements that communities adopt regulations to qualify property owners for insurance was a rational exercise of Congressional power and NFIP sanctions did not constitute a taking of property. (Note, this is not a regulatory case, per se.)

1979 — *American Dredging Co. v. State Dept. of Environmental Protection*, 404 A. 2d 42 (N.J., 1979). Court held an entire 2,500-acre tract that included a floodplain/wetland area was to be viewed in its entirety in determining whether a wetland restriction on 80 acres was reasonable.

— *Foreman v. State Dept. of Natural Resources*, 387 N.E. 2d 455 (Ind., 1979). Court sustained an injunction prohibiting defendants from making deposits on a floodway and compelling removal of deposits previously made in violation of a statute requiring a permit from a state agency for such deposits.

— *County of Ramsey v. Stevens*, 283 N.W. 2d 918 (Minn., 1979). Court indirectly but strongly endorsed Minnesota state floodplain management statute requiring communities on a state list prepared by the Commissioner of Natural Resources to adopt floodplain regulations in order to qualify for the National Flood Insurance Program. The court sustained the decision of a lower court ordering the City Council of Lilydale, Minnesota to adopt regulations within 24 hours.

— *Krahl v. Nine Mile Creek Watershed District*, 283 N.W. 2d 538 (Minn., 1979). Court held that watershed district's floodplain encroachment regulations affecting 2/3 of an 11-acre tract were not an unconstitutional taking of property.

— *Subaru of New England, Inc. v. Board of Appeals of Canton*, 395 N.E. 2d 880 (Mass, 1979). Court upheld denial of permit for construction in flood district based on possible loss of flood storage, public health, safety, and general flood damages.

1980 — *Usdin v. State Dept. of Environmental Protection*, 414 A. 2d 280 (N.J., 1980). Court upheld state floodway regulations prohibiting structures for human occupancy, storage of materials, and depositing solid wastes.

1981 — *Town of Indialantic v. McNulty*, 400 So. 2d 1227 (Fla., 1981). Court upheld against a "taking" challenge a coastal setback line contained in zoning ordinance adopted, in part, to reduce flood damage.

— *Britt v. United States*, 515 F. Supp. 1159 (M.D. Ala., 1981). Court held that the United States was not liable for negligence in the preparation or dissemination of flood hazard boundary maps since they were "flood control" initiatives subject to immunity under the Federal Flood Control Act. (Note, this is not a regulatory case, per se.)

1983 — *Annicelli v. Town of South Kingston*, 463 A. 2d 133 (R.I., 1983). Court held that an unconstitutional taking occurred where local government denied all economic use of barrier island lot based on flooding and environmental concerns.

— *Responsible Citizens in Opposition to the Flood Plain Ordinance v. City of Ashville*, 302 S.E. 2d 204 (N.C., 1983) Court held that a performance standard floodplain regulation was not a taking of private property.

1984 — *C & D Partnership v. City of Gahanna*, 474 N.E. 2d 303 (Ohio, 1984). Court held that City's delay in approval of subdivision plot due to concerns with flooding was justified and discretionary and did not give rise to 1983 action. In addition, City officials acting in good faith were immune from Section 1983 suit.

— *State v. City of La Crosse*, 354 N.W. 2d 738 (Wis. App. 1984). Trial court should not have excluded the result of State's hydraulic analysis showing actual effect of fill on flooding rather than rely on City's floodway line.

1985 — *Society for EED v. New Jersey D.E.P.*, 504 A. 2d 1180 (N.J., 1985). Court held that comprehensive regulations addressing flooding, pollution and preservation of plant and animal life including a 20% net fill rule were not ultra vires and not a taking of property or violation of due process.

— *Oswalt v. County of Ramsey*, 371 N.W. 2d 241 (Minn., 1985.). Court held that a county attempt to eliminate nonconforming use in floodway by denying a permit pursuant to a hazardous condition statute without adequate findings of fact was a taking but landowner award of damages for emotional stress.

— *Sarasota County v. Purser*, 476 So. 2d 1359 (Fla., 1985). Court held that denial of special exception for travel trailer park in federally designated area of special flood hazard was not arbitrary, discriminatory or unreasonable.

— *Ravalese v. Town of East Hartford*, 608 F. Supp. 575 (D. Conn., 1985). Court held that a landowner did not have a constitutionally protected right to have his property excluded from the floodplain maps and that the maps did not take property despite economic impacts.

1986 — *Matcha v. Mattox on Behalf of People of Texas*, 711 S.W. 2d 95 (Tex., 1986). Court held that a property owner could not rebuild cottage after destruction by hurricane because beachline moved due to hurricane erosion and public now had prescriptive right to use beach.

1987 — *Hall v. Board of Environmental Protection*, 528 A. 2d 453 (Me., 1987). Court held that denial of sand dune permit was not an unconstitutional taking where beneficial and valuable uses of property remained despite denial of building permit. Court found that "camping" was an economic use for beachfront property.

— *First English Evangelical Lutheran Church of Glendale v. County of Los Angeles*, 107 S. Ct. 2378 (1987). Court held that if county regulations were a taking, at least temporary compensation would need to be the paid.

1988 — *Adolph v. Federal Emergency Management Agency*, 854 F. 2d 732 (5th Cir., 1988). Federal Court held that Flood Insurance Program and a parish ordinance not a taking of property.

— *Terner v. Spyco, Inc.*, 545 A 2d 192 (N.J Super. A.D., 1988) Court held that township planning board decision granting hardship variance to construct residences within floodplain could not stand without proof of peculiar or exceptional conditions.

— *Reel Enterprises v. City of La Crosse*, 431 N.W. 2d 743 (Wis., 1988). Court held that, as a matter of law, Wis. DNR had not "taken" private floodplain property by undertaking floodplain studies, disapproving municipal ordinance, and announcing an intention to adopt floodplain ordinance for City putting all or most properties within floodway designation. Plaintiff had also failed to allege or prove the deprivation of "all or substantially all, of the use of their property." (Good taking case dealing with the "ripeness issue" and exhaustion of remedies.)

1989 — *Easter Lake Estates, Inc. v. Polk County*, 444 N.W. 2d 72 (Iowa, 1989). Court held that an abatement order that put a mobile home park located on the floodplain beneath a dam out of business was not a taking since the park owner had created the health and safety problem.

— *April v. City of Broken Arrow*, 775 P. 2d 1347 (Okla., 1989). Court held that city floodplain and earth modification ordinances were validly adopted to reduce risks of loss of life and property, protect the public interest in health, preserve the aesthetic environment and fiscal integrity, and enable landowners to purchase flood hazard insurance to protect their investments.

— *American Cyanamid v. D. of Envir. Prot.*, 555 A. 2d 684 (N.J., 1989). Court held that it was permissible for the N.J. DEP to use the USGS "500-year" design floodline and to divide flood hazard area into floodway and flood fringe despite statutory"100-year" flood standard. DEP argued that "500-year" flood reflected "100-year" plus 25% to reflect "future development within the basin."

— *First English Evangelical Lutheran Church of Glendale v. County of Los Angeles*, 258 Cal. Rptr. 893 (Cal., 1989). Court held that county interim floodplain ordinance could not, on the facts, be an unconstitutional taking. On remand from the U.S. Supreme Court decision of the same name (listed previously).

APPENDIX B:
LIST OF ACRONYMS AND ABBREVIATIONS

ACHP	Advisory Council on Historic Preservation
ACRS	Accelerated Cost Recovery System
AEC	Area of Environmental Concern
AFOS	Automation of Field Operations and Services
AHOS	Automatic Hydrologic Observing System
AIRAC	All Industry Research Advisory Council
ALERT	Automated Local Evaluation in Real Time
APA	American Planning Association
ASCS	Agricultural Stabilization and Conservation Service
ASDL	Aircraft Satellite Data Link
ASDSO	Association of State Dam Safety Officials
ASFPM	Association of State Floodplain Managers
ASWM	Association of State Wetland Managers
BFE	Base Flood Elevation
BLH	Bottomland Hardwood
BLM	Bureau of Land Management
BMP	Best Management Practices
BOCA	Building Officials and Code Administrators International, Inc.
BOR	Bureau of Reclamation
c	Centigrade
CAMA	Coastal Area Management Act
CAP	Community Assistance Program
CAPE	Community Assistance Program Evaluation
CAV	Community Assistance Visits
CBO	Congressional Budget Office
CBRA	Coastal Barrier Resources Act
CBRS	Coastal Barrier Resources System
CCJP	Comprehensive, Coordinated, Joint Plan
CCMP	Comprehensive Conservation Management Plan
CDBG	Community Development Block Grant
CEQ	Council on Environmental Quality
CERC	Coastal Engineering Research Center
cfs	Cubic Feet per Second
cm	Centimeter
Corps	U.S. Army Corps of Engineers
CRBS	Cooperative River Basin Studies
CRS	Community Rating System
CSG	Council of State Governments
CSO	Coastal States Organization
CWA	Clean Water Act
CZMA	Coastal Zone Management Act

DAC	Disaster Assistance Center
DFO	Disaster Field Office
DNR	Department of Natural Resources
DOA	Department of the Army
DOC	U.S. Department of Commerce
DOI	U.S. Department of the Interior
DOT	Department of Transportation
DPIG	Disaster Preparedness Improvement Grant Program
DSL	Division of State Lands
DSR	Dam Survey Report
DWR	Division of Water Resources
EENET	Emergency Education Network (FEMA)
EMI	Emergency Management Institute
EO	Executive Order
EOSAT	Earth Observation Satellite Company
EPA	U.S. Environmental Protection Agency
EQ	Environmental Quality
ERL	Environmental Research Laboratories
EROS	Earth Resources Orbiting Satellite
ERTS	Earth Resources Technology Satellites
FAA	Federal Aviation Administration
FCCSET	Federal Coordinating Council for Science, Engineering and Technology
FDAA	Federal Disaster Assistance Administration
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FmHA	Farmers Home Administration
FHBM	Flood Hazard Boundary Map
FHWA	Federal Highway Administration
FIA	Federal Insurance Administration
FIFRA	Federal Insecticide, Fungicide, Rodenticide Act
FIMS	Flood Information Management System
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Studies
FPMS	Floodplain Management Service
FS	U.S. Forest Service
FWS	U.S. Fish and Wildlife Service
GAO	General Accounting Office
GIS	Geographic Information System
GOES	Geostationary Operational Environmental Satellite
GNP	Gross National Product
Ha	Hectare
HCRS	Heritage Conservation and Recreation Service
HD 465	House Document No. 465 (1966)
HEC	Hydrologic Engineering Center
HEP	Habitat Evaluation Procedures
HUD	Department of Housing and Urban Development

ICODS	Interagency Committee on Dam Safety
IDDNHR	International Disaster Decade for Natural Hazards Reduction
IEMIS	Integrated Emergency Management Information System
IEMS	Integrated Emergency Management System
IFLOWS	Integrated Flood Observing and Warning System
IHDA	Illinois Housing Development Authority
IJC	International Joint Commission
IRS	Internal Revenue Service
ISO	Interstate Services Organization
LANDSAT	Land Remote-sensing Satellite
LESA	Land Evaluation and Site Assessment
LFWS	Local Flood Warning System
LMMP	Limited Map Maintenance Program
LWCF	Land and Water Conservation Fund
MHW	Mean High Water
MLW	Mean Low Water
MOA	Memorandum of Agreement
MSL	Mean Sea Level
NACD	National Association of Conservation Districts
NAFSMA	National Association of Flood and Stormwater Management Agencies
NAPP	National Aerial Photography Program
NAS	National Academy of Sciences
NASA	National Aeronautic and Space Administration
NAUFMA	National Association of Urban Flood Management Agencies
NAWID	National Association of Water Institute Directors
NCPI	National Committee on Property Insurance
NCSS	National Cooperative Soil Survey
NED	National Economic Development
NEIC	National Earthquake Information Center
NEPA	National Environmental Policy Act
NERBC	New England River Basin Commission
NESS	National Environmental Science Services
NETC	National Emergency Training Center
NEXRAD	Next Generation Weather Radar
NFIA	National Flood Insurance Act
NFIP	National Flood Insurance Program
NGVD	National Geodetic Vertical Datum (1929)
NHAP	National High Altitude Photography
NHC	National Hurricane Center
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NPDES	National Pollution Discharge Elimination System
NPS	National Park Service
NRC	National Research Council
NRI	National Resource Inventory
NRI	Nationwide Rivers Inventory
NSF	National Science Foundation
NTH	Natural and Technology Hazards
NWF	National Wildlife Federation
NWI	National Wetlands Inventory
NWS	National Weather Service

OBRA	Omnibus Budget Reconciliation Act
OCRM	Office of Ocean and Coastal Resources Management
OMB	Office of Management and Budget
OSTP	Office of Science and Technology Policy
PL	Public Law
PMF	Probable Maximum Flood
ppm	Parts Per Million
P&G	Economic and Environmental Principles and Guidelines for Water and Related Land Resources for Implementation Studies
P&S	Principals and Standards for Planning of Water and Related Land Resources
PTWC	Pacific Tsunami Warning Center
RBC	River Basin Commission
RFC	River Forecast Center
ROM	Read Only Memory
SAP	State Assistance Program
SBCCI	Southern Building Code Congress International, Inc.
SBA	Small Business Administration
SCORP	State Comprehensive Outdoor Recreation Plan
SCS	Soil Conservation Service
SHPO	State Historic Preservation Officers
SLOSH	Sea, Lake and Overland Surges from Hurricanes
SPF	Standard Project Flood
SPLASH	Special Program to List Amplitudes of Surges from Hurricanes
STORET	Storage and Retrieval (EPA's Water Quality Data Base)
SWMM	Stormwater Management Model
TDR	Transfer of Development Rights
TRA	Tax Reform Act of 1986
TVA	Tennessee Valley Authority
UNP	Unified National Program for Floodplain Management
USCOLD	U.S. Committee On Large Dams
USDA	U.S. Department of Agriculture
USDNR	U.S. Decade for Natural Disasters Reduction
USGS	U.S. Geological Survey
WATSTORE	National Water Data Storage and Retrieval System
WET	Wetland Evaluation Technique
WFSO	Weather Field Service Offices
WHAFIS	Wave Height Analysis, Flood Insurance Study
WSO	Local Weather Services Offices
WSP-2	Water Surface Profile 2
WSPRO	Water Surface Profile Model
WRC	U.S. Water Resources Council
WRI	Water Resources Institute
WYO	Write Your Own

APPENDIX C:
GLOSSARY[1]

A Unified National Program for Floodplain Management: A concept (and document of the same name) establishing the foundation of a coordinated national effort to manage the Nation's floodplains. The Unified National Program recommends a continuing unified program for planning and action at all levels of government to reduce the risk of flood losses and to protect floodplain values. The document was originally prepared by the U.S. Water Resources Council in 1976 in response to a directive of the 1968 National Flood Insurance Act, and subsequently revised and updated in 1979 and 1986.

Actuarial Rates: Insurance rates determined on the basis of a statistical calculation of the probability that a certain event will occur. Actuarial rates are also called "risk premium rates." They are established by the Federal Insurance Administration pursuant to individual community Flood Insurance Studies and investigations that are undertaken to provide flood insurance in accordance with the National Flood Insurance Act and with accepted actuarial principles, including provisions for operating costs and allowances.

Alluvial Fan: Deposits of rock and soil that have eroded from mountainsides and accumulated on valley floors in a fan-shaped pattern and which occur mainly in dry mountainous areas.

Association of State Floodplain Managers: An organization of persons concerned with floodplain management; formed in 1977 to provide a forum for the sharing of expertise and experience with regard to state and local floodplain management problems and to assist with efforts to improve the effectiveness of those programs.

A-Zone: That portion of the coastal floodplain as marked on maps prepared by the Federal Emergency Management Agency that is likely to be inundated by the one-percent ("100-year") flood and not subject to wave action. The A-zone, however, may be subject to residual forward momentum of breaking waves. The A-zone and the V-zone together form the Coastal Special Flood Hazard Area.

Base Flood: The selected flood frequency for regulatory purposes. The NFIP has adopted the "100-year" flood as the base flood to indicate the minimum level of flooding to be used by a community in its floodplain management regulations.

Bottomland Hardwoods: Tree species that occur on water-saturated or regularly inundated soils. Classified as wetlands, these areas contain both trees and woody shrubs.

Breakwaters: Structures, usually built offshore, to protect a shore area, harbor, anchorage or basin by intercepting the energy of approaching waves.

Bulkhead: A vertical wall of wood, steel or concrete, built parallel to the shoreline and designed to deflect waves and control erosion.

Carrying Capacity: A term most generally used to refer to the level of use or extent of modification an environmental or man-made system may bear without experiencing unacceptable resource deterioration or degradation.

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[1] The definitions of terms contained in this glossary are for the purpose of the *Assessment Report* only. The meaning and use of the terms included here may differ in federal and state laws and regulations.

Coastal Barrier: Elongated, offshore formations of sand and other unconsolidated sediments lying generally parallel to mainland coastlines; including bay barriers (connected to headlands on both ends), barrier spits (connected on one end), and barrier islands (bounded on one side by inlets without attachment to the mainland).

Coastal High Hazard Area: The area subject to high velocity waters, including, but not limited to, hurricane wave wash or tsunamis. The area is designated on a FIRM as Zone V1-30.

Community Assistance Program (CAP): The program established by the Federal Insurance Administration and intended to assure that communities participating in the NFIP are carrying out the flood loss reduction objectives of the program. The CAP provides needed technical assistance to NFIP communities and attempts to identify and resolve floodplain management issues before they develop into problems requiring enforcement action.

Community Rating System (CRS): A program developed by the Federal Insurance Administration to encourage — by use of flood insurance premium adjustments — community and state activities that go beyond the basic NFIP requirements; the CRS gives communities "credit" for certain activities to reduce flood losses, facilitate accurate insurance rating, and promote the awareness of flood insurance.

Conservation Tillage: Practices that reduce cultivation of soil, leave a protective vegetative layer on the surface, and thereby serve to reduce or minimize soil erosion.

Control Basin: Also called a sediment basin, and used in fields to control runoff and sediment where terraces are impractical due to topography.

Cultural Resource Values: Floodplain values associated with the harvest of natural products (agricultural, aquacultural and forestry uses), as well as historical/archaeological, scientific and recreation/open space values.

Cumulative Impacts: The impacts on the environment that result from the incremental impact of an action when added to other past, present and reasonably foreseeable actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

Deepwater Habitats: Permanently flooded areas having a depth of greater than two meters.

Dike: A general term for longitudinal barriers that confine floodwaters to the river channel and thereby help to protect floodprone areas.

Diversion: A structural flood control measure that intercepts flood flows upstream of a damage-prone or constricted area and routes flood flows around the area through an artificial channel or designated flow-way.

Diversion Channel: A vegetated channel constructed across the slope of a field to catch water and carry it off a field.

Drainage Area: The total land area where surface water runs off and collects in a stream or series of streams that make up a single watershed.

Dune Stabilization: The most frequently used type of land treatment in coastal areas, including protection or establishment of plant cover on existing sand dunes and/or construction of replacement dunes.

Emergency: Any instance for which, in the determination of the President, federal assistance is needed to supplement state and local efforts and capabilities to save lives and protect property and public health and safety or to lessen or avert the threat of a disaster in any part of the United States.

Emergency Program: The interim program of the National Flood Insurance Program as implemented on an emergency basis to provide a first layer of subsidized insurance before the detailed risk studies from which actuarial rates are computed have been completed.

Encroachments: Activities or construction within the floodway (including fill, new construction, substantial improvements, and other development) that result in an increase in flood levels.

Environmental Assessment: An examination of the positive and adverse impacts on the environment of a proposed water resources solution and alternative solutions.

Environmental Impact Statement: A detailed environmental analysis and documentation of a proposed water resources solution when the proposed solution is expected to have a significant effect on the quality of the human environment or the area's ecology.

Erosion: The process of the gradual wearing away of land masses.

Estuary: A confined coastal water body with an open connection to the sea and a measurable quantity of salt in its waters.

Executive Order 11988: The "Floodplain Management" Executive Order issued by the President and which specifies the responsibilities of federal agencies in floodplain management. E.O. 11988 directed federal agencies to evaluate and reflect the potential effects of their actions on floodplains and to include the evaluation and consideration of flood hazards in agency permitting and licensing procedures.

Exceedance Probability: The average frequency with which a flood of a particular magnitude will be exceeded; expressed as the probability that a flood will be exceeded in any year (the annual exceedance probability) or as the average recurrence interval (the n-year flood).

Federal Interagency Floodplain Management Task Force: The Task Force established in 1975 to carry out the responsibility of the President to prepare for the Congress a Unified National Program for Floodplain Management; member agencies are the Department of Agriculture, Department of Army, Environmental Protection Agency, Federal Emergency Management Agency, Department of Interior, and the Tennessee Valley Authority.

Fetch: The horizontal distance (in the direction of the wind) over which the wind generates waves or creates a wind setup.

Flash Flood: Flooding characterized by a rapid rise in water, high velocity, and large amounts of debris.

Flood/Flooding: A general and temporary condition of: 1) partial or complete inundation of normally dry land areas from the overflow of inland and/or tidal waters; and/or 2) the unusual accumulation of waters from any source.

Flood Control Structures: Structures such as dams, dikes, levees, drainage ditches, and other structures built to modify flooding and protect areas from flood waters.

Flood Discharge: The total quantity of water flowing in a stream and adjoining overflow areas during times of flood. It is measured by the amount of water passing a point along a stream within a specified period of time and is usually measured in cubic feet of water per second (cfs)

Flood Frequency: The frequency with which a flood of a given discharge has the probability of recurring. For example, a "100-year" frequency flood refers to a flood discharge of a magnitude likely to occur on the average of once every 100 years or, more properly, has a one-percent chance of being exceeded in any year. Although calculation of possible recurrence is often based on historical records, there is no guarantee that a "100-year" flood will occur at all within the 100-year period or that it will not recur several times.

Flood Fringe: Areas outside the regulatory floodway but still within the designated one percent annual chance floodplain and often referred to as the floodway fringe.

Flood Hazard: The potential for inundation that involves risk to life, health, property, and natural floodplain values.

Flood Hazard Boundary Map (FHBM): The first flood risk map prepared for a community which identifies flood hazard areas based on approximation of the land area in the community having a one percent or greater chance of being flooded in a given year. The FHBM is an official map of a community, issued through the NFIP, where the boundaries of the flood, mudslide (i.e., mudflow), and related erosion areas having special hazards have been designated as Zone A, M, or E.

Flood Hazard Mitigation Teams: Teams consisting of representatives of the 12 federal agencies that signed an interagency agreement to provide technical assistance to states and communities for nonstructural flood damage reduction measures. The teams are typically employed after each major flood disaster declared by the President to provide technical assistance and guidelines to communities and states affected by the disaster.

Flood Insurance: The insurance coverage provided through the National Flood Insurance Program.

Flood Insurance Rate Map (FIRM): An official map of a community on which the Federal Emergency Management Agency has delineated both the special hazard areas and the risk premium zones applicable to the community. FIRMs identify the elevation of the one percent annual chance flood and the areas that would be inundated by that level of flooding, and are used to determine flood insurance rates.

Flood Insurance Study (FIS): An examination, evaluation, and determination of flood hazards and, if appropriate, corresponding water surface elevations, or an examination, evaluation, and determination of mudslide (i.e., mudflow) and/or flood-related erosion hazards.

Floodplain: Low lands adjoining the channel of a river, stream or watercourse, or ocean, lake or other body of water, which have been or may be inundated by flood water, and those other areas subject to flooding.

Floodplain Management: The operation of an overall program of corrective and preventive measures for reducing flood damage, including but not limited to emergency preparedness plans, flood control works, and floodplain management regulations.

Floodplain Management Regulations: Zoning ordinances, subdivision regulations, building codes, health regulations, special purpose ordinances (covering, for example, floodplains, grading, and erosion control) and other regulations to control future development in floodplains and to correct inappropriate development already in floodplains.

Floodplain Resources: Natural and cultural resources including wetlands, surface water, groundwater, soils, historic sites, and other resources that may be found in the floodplain and which provide important water resources, living resources (habitat), and cultural/historic values.

Floodplain Values: The qualities of or functions served by floodplains which include but are not limited to: a) water resource values (natural moderation of floods, water quality maintenance, groundwater recharge); b) living resource values (fish, wildlife, plant resources and habitats); c) cultural resource values (open space, natural beauty, scientific study, outdoor education, archaeological and historic sites, recreation); and d) cultivated resource values (agriculture, aquaculture, forestry).

Floodproofing: The modification of individual structures and facilities, their sites, and their contents to protect against structural failure, to keep water out, or to reduce the effects of water entry.

Floodwall: Reinforced concrete walls that act as barriers against floodwaters and confine them to the river channel, thereby helping to protect floodprone areas. Floodwalls are usually built in areas with a limited amount of space.

Floodway: The channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height. The floodway is intended to carry the deep and fast-moving water. Normally the base flood is defined as the one percent chance flood and the designated height is one foot above the prefloodway condition.

Fluctuating Lake Levels: Short- or long-term water level fluctuations that can cause high water and subsequent flooding problems and which can result from natural and man-induced events.

Foreshore: The strip of coastal land between the high and low water marks and that is alternately wet and dry according to the ebb and flow of the tide.

Freeboard: A factor of safety usually expressed in feet above a flood level for purposes of floodplain management. "Freeboard" tends to compensate for the many unknown factors that could contribute to flood heights greater than the height calculated for a selected size flood and floodway conditions, such as wave action, bridge openings, and the hydrological effect of urbanization of the watershed.

Geographic Information System (GIS): A computerized system designed to collect, manage, and analyze large volumes of spatially referenced and associated attribute data.

Groin: Barrier-type structures that extend from the backshore into the littoral zone used to retard longshore transport of sediment in the littoral zone and generally constructed parallel to the shoreline.

Habitat Evaluation Procedure (HEP): A methodology developed by the U.S. Fish and Wildlife Service for quantitative evaluation of the suitability of wetlands and other habitat types for fish and wildlife species.

House Document 465: The 1966 report of the Bureau of the Budget Task Force on Federal Flood Control Policy, entitled *A Unified National Program for Managing Flood Losses*, and advocating a broader perspective on flood control within the context of floodplain development and use.

Hurricane: A warm-core tropical cyclone in which the maximum sustained surface wind (1 minute mean) is greater than or equal to 64 knots (73.6 mph).

Hydraulics: The science dealing with the mechanical properties of liquids that describes the specific pattern and rate of water movement in the environment.

Hydrology: The science dealing with the properties, distribution and circulation of water on the surface of the land, below the surface, and in the atmosphere.

Ice Jam: A barrier to streamflow that may occur when ice cover breaks up into large floating masses that lodge at bridges or other constrictions. Rapid flooding may occur, first upstream, then downstream, as the mass of ice finally breaks free.

Integrated Emergency Management System (IEMS): A program developed by the Federal Emergency Management Agency to promote development of integrated emergency preparedness plans that address all types of natural and technological hazards.

Jetty: A structure used at inlets to stabilize the position of a navigation channel, to shield vessels from wave forces, and to control the movement of sand along adjacent beaches to minimize the movement of sand into a channel.

Land Treatment Measures: Measures used to reduce runoff of water to streams or other areas; techniques include: maintenance of trees, shrubbery and vegetative cover; terracing; slope stabilization; grass waterways; contour plowing; and strip farming.

Landslide: An extreme form of erosion which is a natural process of the earth's surface and occurs when external forces exceed internal forces within the soil and rock of a hillside.

Levee: A linear structure extending from high ground adjacent to a floodprone area along one side of a river to another area of high ground on the same side of the river.

Liquefaction: A type of ground failure triggered by earthquakes and which occurs when seismic shock waves pass through unconsolidated and saturated soil.

Littoral: Of or pertaining to the shore, especially of the sea.

Littoral Drift: The movement of sand by littoral (longshore) currents in a direction generally parallel to the beach along the shore.

Major Disaster: Any natural catastrophe or, regardless of cause, any fire, flood, or explosion in any part of the United States which in the determination of the President, causes damage of sufficient severity and magnitude to warrant major disaster assistance under the Robert T. Stafford Disaster Relief and Emergency Assistance Act.

Mean High Water (MHW): The average height of the maximum elevation reached by each rising tide over a specific 19-year period. MHW is the reference base for structure heights, bridge clearances, etc.

Mean Low Water (MLW): The average height of the minimum elevation reached by each falling tide over a specific 19-year period. All depth measurements in coastal waters and all depths shown on navigation charts are referenced to MLW.

Mean Sea Level (MSL)/ Mean Tide Level (MTL): MSL is the arithmetic mean of hourly heights observed over a specific 19-year period. MSL is very nearly the same as Mean Tide Level. MTL (also known as half-tide level) is the arithmetic mean of mean high water and mean low water.

Mitigation: Any action taken to permanently eliminate or reduce the long-term risk to human life and property and the negative impacts on natural and cultural resources that can be caused by natural and technological hazards.

Mitigation Banking: An alternative for compensating for the unavoidable impacts of development in wetlands where mitigative measures cannot be achieved at or near the site of impact.

Mudflood: A flood in which the water carries heavy loads of sediment, including coarse debris; typically occurring in drainage channels and on alluvial fans adjacent to mountainous areas.

Mudflow: A specific subset of landslides where the dominant transporting mechanism is that of a flow having sufficient viscosity to support large boulders within a matrix of smaller sized particles.

National Flood Insurance Program (NFIP): established by the National Flood Insurance Act of 1968 to provide relief from the impacts of flood damages in the form of federally subsidized flood insurance that became available to participating communities, contingent on nonstructural flood loss reduction measures embodied in local floodplain management regulations. The NFIP is designed to reduce future flood losses through state and local floodplain management efforts and to transfer the costs of residual flood losses from the general taxpayer to the floodplain occupant.

National Geodetic Vertical Datum (NGVD): A fixed reference adopted as a standard geodetic datum for elevation in the United States. For land-based vertical measurements, NGVD is usually given a value of 0.0 and all other points are measured according to their distance above or below.

National Wetlands Inventory Project: Wetlands mapping on a national basis performed by the U.S. Fish and Wildlife Service to provide scientific information on the extent and characteristics of the Nation's wetlands and consisting of detailed maps and status and trends reports.

No Net Loss: A term used in wetlands protection and restoration programs with the intent to reduce the cumulative impacts of wetland losses; no net loss determinations may be based on acreage and/or functional value of wetlands.

Nonstructural Measures: A term originally devised to distinguish techniques that modify susceptibility to flooding (such as regulation, floodplain acquisition and floodproofing techniques) from the more traditional structural methods (such as dams, levees, and channels) used to control flooding.

Northeaster: An extratropical storm that occurs along the northern part of the east coast of the United States, accompanied by strong winds from the northeast quadrant.

100-year Flood: A term commonly used to refer to the one percent annual chance flood. The "100-year" flood is the flood that is equaled or exceeded once in 100 years on the average, but the term should not be taken literally as there is no guarantee that the "100-year" flood will occur at all within the 100-year period or that it will not recur several times.

One-Percent Annual Chance Flood: A flood of the magnitude that has a one-percent chance of being equalled or exceeded in any given year. Often referred to as the "100-year" flood or base flood, the one-percent annual chance flood is the standard most commonly used for floodplain management and regulatory purposes in the United States.

Overbank Flooding: The increase in volume of water within a river channel and the overflow of water from the channel onto the adjacent floodplain.

Overwash: Storm waves that wash across the beach and onto adjacent land areas.

Principles and Standards/Principles and Guidelines: "The Principles and Standards for Planning of Water and Related Land Resources" is a Presidential policy statement issued in September 1973 which established a framework for improved planning for the use of water and related land resources based on the objectives of National Economic Development and Environmental Quality. The "Principles and Standards" were revised and issued as the "Economic and Environmental Principles and Guidelines for Water and Related Land Resources for Implementation Studies."

Public Trust Doctrine: The doctrine based on the common law principle that certain lands and waters are so important to the public that private ownership or other impediments to public uses should not be permitted. Under the Public Trust Doctrine, the coastal states generally hold title to the foreshore, open tidal waters, and submerged land under tidal waters seaward of the mean high water line as trustee for the public and must administer the use of these lands in the public interest.

Recurrence Interval: The average interval in which a flood of a given size is equaled or exceeded as an annual maximum.

Regional Flood: A term used by the Tennessee Valley Authority to estimate a flood comparable in magnitude to the largest known floods on similar streams within approximately 100 miles for purposes of local flood damage prevention planning.

Regular Program: The phase of the National Flood Insurance Program in which communities participate once risk studies have been completed or it is determined that detailed risk studies are not required because of low flood risk.

Regulatory Floodplain: The area adjoining a river, stream, lake or ocean that is inundated by a regulatory flood. In riverine areas, the floodplain usually consists of a regulatory floodway and regulatory flood fringe (also referred to as a floodway fringe). In coastal areas, the floodplain may consist of a single regulatory floodplain area or a regulatory high hazard area and a regulatory low hazard area.

Regulatory Floodway: The area regulated by federal, state or local requirements to provide for the discharge of the base flood so the cumulative increase in water surface elevation is no more than a designated amount (not to exceed one foot as set by the National Flood Insurance Program).

Regulatory Flood Fringe: The portion of the regulatory floodplain beyond the limits of the regulatory floodway. The regulatory flood fringe is subject to less frequent and lower velocity flooding and does not play a major role in passing flood flows.

Repetitive Loss: A flood-caused loss of more than $1,000 to a repetitive loss structure.

Repetitive Loss Structure: A structure for which two or more losses of more than $1,000 (building and contents combined) have been paid during the most recent 10-year period.

Retrofitting: Floodproofing of existing structures.

Riparian Ecosystems: Distinct associations of soil, flora and fauna occurring along a river, stream, or other body of water and dependent for survival on high water tables and occasional flooding.

Riparian/Littoral Rights: The rights of an owner of land contiguous to a navigable body of water. If the water in question is flowing (e.g., river or stream) the rights are said to be riparian. If the property is subject to the ebb and flow of the tide, the rights are said to be littoral rights. The terms "riparian" and "littoral" are commonly used interchangeably. Riparian/littoral rights are usually defined to include: a) the use of the water for general purposes such as swimming; and b) the right of access to navigable waters, including the right to wharf out to navigability.

Risk: The probability of being flooded.

Saffir/Simpson Hurricane Scale: Scale, adopted for use by the National Hurricane Center, that relates hurricane intensity to damage potential.

Seawall: A wall built parallel to the shore, designed to halt shoreline erosion by absorbing the impact of waves.

Section 10 and 404 Regulatory Programs: The principal federal regulatory programs, carried out by the U.S. Army Corps of Engineers, affecting structures and other work below mean high water. The Corps, under Section 10 of the River and Harbor Act of 1899, regulates structures in, or affecting, navigable waters of the U.S. as well as excavation or deposition of materials (e.g., dredging or filling) in navigable waters. Under Section 404 of the Federal Water Pollution Control Act Amendments (Clean Water Act of 1977), the Corps is also responsible for evaluating application for Department of the Army permits for any activities that involve the placement of dredged or fill material into waters of the United States, including adjacent wetlands.

Section 409 Hazard Mitigation Plan: A plan prepared as required by Section 409 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988 by any jurisdiction that receives federal disaster assistance.

Setback Standards: Minimum distances established by regulation that structures must be set back from river channels and coastal shorelines.

Special Hazards: Hazards that accompany flooding and cause greater damage than the usual forces of flowing water. Special hazard areas include areas below dams, areas behind levees, alluvial fans, and areas subject to mudfloods.

Standard Project Flood: A very large (low frequency) design flood standard applied to the design of major flood control structures and representing the most severe combination of meteorological and hydrological conditions considered reasonably characteristic of a particular region.

Standards: Floodplain regulatory and design standards, including prescriptive and performance standards, that provide a means for uniform application of floodplain management practices and for the review and evaluation of flood loss reduction and natural values protection projects.

State Coordinating Agency: The agency of a state government or other office designated by a state governor or by state statute at the request of the NFIP Administrator to assist in the implementation of the National Flood Insurance Program in that state.

Step-Backwater Analysis: The most widely used method for calculating river hydraulics.

Still-Water Elevation: The estimated height of the water surface during a coastal storm as generated by the storm surge and the astronomical tide. Measured in relation to NGVD, the estimated still-water elevation does not include the added effects of waves on the water surface elevation. The still-water elevation associated with the one-percent flood is referred to on maps prepared by the Federal Emergency Management Agency as the Base Flood Elevation.

Storm Surge: The increase in water surface elevation above normal tide levels due primarily to atmospheric pressure reduction and the piling up of water in coastal areas due to the cumulative effects of wind stress acting in essentially a constant direction across an open expanse of water.

Strategies and Tools: The management strategies and implementing tools established in House Document 465 to guide federal, state and local decision-makers in implementing a national program for floodplain management.

Structural Measures: Measures such as dams, reservoirs, dikes, levees, floodwalls, channel alterations, high flow diversions and spillways, and land treatment measures designed to modify floods.

Subsidence: A type of ground failure that can lower the ground surface, causing or increasing flood damage in areas of high ground water, tides, storm surges, or overbank stream flow.

Substantial Damage: The amount of damage to a structure caused by flooding that may be sustained before certain regulatory and flood insurance requirements are triggered. As defined in NFIP regulations, a building is considered substantially damaged when the cost of restoring the building would exceed 50% of the market value of the structure.

Substantial Improvement: Any repair, reconstruction or improvement of a structure, the cost of which equals or exceeds 50% of the market value of the structure either a) before the improvement or repair is started, or b) if the structure has been damaged, and is being restored, before the damage occurred.

Terrace: A technique to reduce soil erosion, often consisting of an earthen embankment, channel or combination of ridge and channel constructed across a slope.

Tidal Wave: A term used inappropriately to refer to tsunamis (seismic sea waves).

Tropical Cyclone: Storms of various intensities that form over warm tropical and subtropical waters; classified according to intensity and degree of organization and including tropical disturbances, tropical depressions, tropical storms, and hurricanes.

Tropical Storm: A warm-core tropical cyclone in which the maximum sustained surface wind (1 minute mean) ranges from 34 to 63 knots (39-72.5 mph).

Tsunami: Long-period, low-height sea waves of seismic origin; generated principally by undersea earthquakes of magnitudes greater than 6.5 on the Richter scale.

Typhoon: Pacific Ocean hurricanes that develop in the regions off Mexico and Central America.

V-zone: The velocity zone, or the portion of the coastal floodplain as marked on maps prepared by the Federal Emergency Management Agency that is subject to high velocity waters from wave action associated with the one-percent annual chance flood. Also called the coastal high hazard area, the V-zone is usually determined by the area subject to wave heights of three feet or greater.

Vertical Evacuation: The use of higher rise structures as "vertical refuges" during a flood or hurricane.

Vulnerability: Characterization of the nature and extent of damage that may occur during flooding.

Watershed: A region or area contributing ultimately to the water supply of a particular watercourse or water body.

Water Resources Values: Floodplain values including those related to natural storage and conveyance of flood waters, the maintenance of water quality, and the recharge of groundwater.

Waters of the United States: Currently defined by regulation to include all navigable and interstate waters, their tributaries and adjacent wetlands, as well as isolated wetlands and lakes and intermittent streams.

Wave Crest Elevation: The height, measured above NGVD, of wave crests in the coastal floodplain during a coastal storm, including the height of wind-generated waves as well as the effects of the tide and surge.

Wave Run-Up: The action of a wave after it breaks and the water "runs up" the shoreline or other obstacle, flooding areas reached by the storm surge itself.

Wave Set-Up: The super-elevation of the water surface over normal surge elevation due to onshore mass transport of the water by wave action alone.

Wetlands: Those areas that are inundated by surface or groundwater with a frequency sufficient to support and, under normal circumstances, does or would support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include bottomland hardwoods, swamps, marshes, bogs, and similar areas such as sloughs, potholes, wet meadows, river overflows, mud flats, and natural ponds.

Wetland Evaluation Technique: A technique used by the Corps of Engineers, the Federal Highway Administration, and the Environmental Protection Agency to rapidly assess wetland functions and values.

Wind Setup: The vertical rise in the stillwater level on the leeward side of a body of water caused by wind stresses acting on the surface of the water.

Write-Your-Own Program: An effort to involve private insurance companies in the National Flood Insurance Program, and consisting of a policy sales and servicing mechanism by which insurance agents can sell flood insurance policies through individual property and casualty insurance companies.

APPENDIX D:

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APPENDIX E:

AGENCIES AND ORGANIZATIONS INVITED TO COMMENT ON THE STATUS REPORT AND ON THE EFFECTIVENESS OF FLOODPLAIN MANAGEMENT[1]

GOVERNMENT AGENCIES

Federal Emergency Management Agency*
Federal Insurance Administration

International Boundary and Water Commission*
United States and Mexico

Tennessee Valley Authority*
Floodplain Management Program

U.S. Department of Agriculture*
Soil Conservation Service

U.S. Department of the Army*
U.S. Army Corps of Engineers

U.S. Department of Commerce*
National Oceanic and Atmospheric Administration
Estuarine Programs Office

U.S. Department of Commerce
National Weather Service

U.S. Department of Housing and Urban Development

U.S. Department of the Interior*
Bureau of Reclamation

U.S. Department of the Interior*
National Park Service

U.S. Department of the Interior*
Office of Environmental Project Review

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of Transportation*
Federal Highway Administration

U.S. Environmental Protection Agency
Office of Federal Activities

U.S. Environmental Protection Agency*
Office of Wetlands Protection

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1 In 1989, the Federal Interagency Floodplain Management Task Force sent letters to the representatives of 15 government agencies and 56 professional and nonprofit organizations requesting their comments on the *Status Report* and on the effectiveness of floodplain management. Specific questions pertaining to the *Status Report* were prepared and sent to each invited reviewer. This appendix lists the agencies and organizations invited to comment, and includes copies of the letters and questions sent to each. Those that provided comments are noted with an asterisk (*). The comments provided were incorporated into the *Assessment Report* where appropriate and are available from the Federal Interagency Floodplain Management Task Force on request.

PROFESSIONAL AND NONPROFIT ORGANIZATIONS

All Industry Research Advisory Council*

American Institute of Architects Foundation

American Planning Association*

American Public Works Association

American Red Cross*

American Rivers

American Society of Civil Engineers

American Water Resources Association

Association of Conservation Engineers

Association of State Dam Safety Officials*

Association of State Floodplain Managers, Inc.*

Association of State River Managers

Association of State Water and Interstate Pollution Control Agencies

Association of Wetland Managers, Inc.*

Building Officials & Code Administrators, International

Coastal States Organization

The Conservation Foundation and Wildlife Fund

Council of State Governments

Environmental Defense Fund, Inc.

Environmental Policy Institute

Friends of the River Foundation

International Congress of Building Officials

Interstate Conference on Water Problems

Isaak Walton League of America

National Association of Conservation Districts*
National Association of Counties

National Association of Flood & Stormwater Management Agencies*

National Association of Home Builders

National Association of State Research Planners

National Association of Towns and Townships

National Association of Water Institute Directors*

National Audubon Society

National Committee on Property Insurance*

National Conference of State Legislatures

National Governor's Association

National Institute for Urban Wildlife

National League of Cities

National Organization for River Sports

National Recreation and Park Assoc.

National Waterways Conference

National Wetlands Technical Council

National Wildlife Federation

Natural Hazards Research & Applications Information Center

The Nature Conservancy, Inc.

North American Lake Management Society

Sierra Club*

Society for Ecological Restoration and Management

Soil and Water Conservation Society

Southern Building Code Congress International, Inc.*

Trust for Public Land

The Urban Land Institute*

Water Science and Technology Board

Wetlands Research, Inc.

Wetlands for Wildlife

Wilderness Society

Wildlife Management Institute*

LETTER SENT TO REPRESENTATIVES OF GOVERNMENT AGENCIES

TVA

Tennessee Valley Authority 400 West Summit Hill Drive Knoxville Tennessee 37902

IDENTICAL LETTER SENT TO THOSE ON ATTACHED LIST

June 1, 1989

Mr. Bruce Brown
Land Resources Management Branch
Bureau of Reclamation
Main Interior Building
Washington, D.C. 20240

Dear Mr. Brown:

You are being sent under separate mailing the requested number of copies of a report entitled "A Status Report on the Nation's Floodplain Management Activity." They are being sent to you to obtain your agency's review of this document and to assist in the evaluation of the status and effectiveness of floodplain management efforts. Should you need additional copies, please contact me.

This report was prepared by a work group of the Federal Interagency Task Force on Floodplain Management, of which your agency is a member or participant. The task force is responsible for following up on recommendations to the President and the Congress contained in an earlier report by the task force entitled A Unified National Program for Floodplain Management. You should have copies of this report. Additional copies are available from the Federal Emergency Management Agency.

One of the recommendations in the "Unified National Program" document is to "provide evaluation of floodplain management activities with periodic reporting to the public and to the Congress on progress toward implementation of 'A Unified National Program for Floodplain Management'." The enclosed report is the first segment of a three-year effort to fulfill the above recommendation. It represents a compilation of both known and available information about the background and current status of floodplain management. Despite our goals to include all relevant information, to adequately discuss all topics, and to provide balance in the treatment of subjects, there may be important information and data that have been omitted that should be included in a report on the status of the Nation's floodplains. Thus, this document is an interim status report.

LETTER SENT TO REPRESENTATIVES OF GOVERNMENT AGENCIES
(Continued)

-2-

Mr. Bruce Brown

June 1, 1989

In addition to serving as a status report, it will also be a foundation for evaluating the degree of success or failure of the basic strategies and tools utilized to reduce the loss of human life and property and maintaining natural and beneficial floodplain values. Evaluations and comments on this (interim) status report obtained from the task force agencies, national organizations, and from other experts will be compiled and used by the task force in preparing a second report on the effectiveness of the various strategies and tools for achieving the above floodplain management goals. Your evaluations and comments will also be used as input for developing a final status report. Finally, the task force will utilize the status and evaluation reports for updating A Unified National Program for Floodplain Management.

We would like your agency's views as to the adequacy of the status report in describing what is happening in the Nation's floodplains, but we would particularly like its perspectives on the effectiveness of the various floodplain management strategies and tools and recommendations for improving their implementation and use. Because a large number of agencies and organizations are being invited to contribute their assistance, you are requested to attempt to organize the comments and recommendations of your agency accordant to the enclosed questions. These represent questions for which the task force is particularly interested in obtaining your views. Of course, any additional thoughts and views will be welcomed. Your agency's comments will be compiled along with others and become a part of this study and will be made available for further reference and use.

So that the views and comments of your agency might be used in carrying out an evaluation of the effectiveness of floodplain management and in preparing the final status report, we would appreciate receiving your comments by August 30 at the above address. Should you have any questions in preparing your comments, I can be contacted at (615) 632-4792.

The task force work group has asked me to emphasize to you the importance of receiving your agency's views and comments. For this reason, we hope you will be able to provide us with this valuable assistance.

Thank you in advance for taking the time and making this effort.

Sincerely,

James M. Wright
Project Manager

Enclosures

LETTER SENT TO REPRESENTATIVES OF PROFESSIONAL AND NONPROFIT ORGANIZATIONS

TVA

Tennessee Valley Authority, 400 West Summit Hill Drive, Knoxville, Tennessee 37902

IDENTICAL LETTER SENT TO THOSE ON ATTACHED LIST

May 30, 1989

Ms. Diane Vande Hei
National Association of Flood and
Stormwater Management Agencies
1225 Eye Street, NW., Suite 300
Washington, D.C. 20005

Dear Ms. Hei:

Enclosed is a copy of a report entitled "A Status Report on the Nation's Floodplain Management Activity." It is being sent to you as a representative of an organization with knowledge or concerns regarding our floodplains. Your organization's evaluation of the status and effectiveness of floodplain management efforts is sought to improve floodplain management at the local, state, and Federal levels. A limited number of additional copies of the report are available from this office upon request for your use in assisting us.

This report was prepared by the Federal Interagency Task Force on Floodplain Management, which is responsible for following up on recommendations to the President and the Congress contained in an earlier report by the task force entitled A Unified National Program for Floodplain Management. Also enclosed is a document entitled "Conceptual Framework and Basic Strategies and Tools for Implementing A Unified National Program for Floodplain Management" which provides relevant materials excerpted from the earlier report. Additional copies are also available upon request.

One of the recommendations in the "Unified National Program" document is to "provide evaluation of floodplain management activities with periodic reporting to the public and to the Congress on progress toward implementation of 'A Unified National Program for Floodplain Management'." The enclosed report is the first segment of a three-year effort to fulfill the above recommendation. It represents a compilation of both known and available information about the background and current status of floodplain management. Despite our goals to include all relevant information, to adequately discuss all topics, and to provide balance in the treatment of

LETTER SENT TO REPRESENTATIVES OF PROFESSIONAL AND NONPROFIT ORGANIZATIONS
(Continued)

-2-

Ms. Diane Vande Hei May 30, 1989

subjects, there may be important information and data that have been omitted that should be included in a report on the status of the Nation's floodplains. Thus, this document is an interim status report.

In addition to serving as a status report, it will also be a foundation for evaluating the degree of success or failure of the basic strategies and tools utilized to reduce the loss of human life and property and maintaining natural and beneficial floodplain values. Evaluations and comments on this (interim) status report obtained from organizations such as yours and from other experts will be compiled and used by the task force in preparing a second report on the effectiveness of the various strategies and tools for achieving the above floodplain management goals. Your evaluations and comments will also be used as input for developing a final status report. Finally, the task force will utilize the status and evaluation reports for updating A Unified National Program for Floodplain Management.

We would like your organization's views as to the adequacy of the status report in describing what is happening in the Nation's floodplains, but we would particularly like its perspectives on the effectiveness of the various floodplain management strategies and tools and recommendations for improving their implementation and use. Because a large number of agencies and organizations are being invited to contribute their assistance, you are requested to attempt to organize the comments and recommendations of your organization accordant to the enclosed questions. These represent questions for which the task force is particularly interested in obtaining your views. Of course, any additional thoughts and views will be welcomed. Your organization's comments will be compiled along with others and become a part of this study and will be made available for further reference and use.

So that the views and comments of your organization might be used in carrying out an evaluation of the effectiveness of floodplain management and in preparing the final status report, we would appreciate receiving your comments by August 30 at the above address. Should you have any questions in preparing your comments, I can be contacted at (615) 632-4792.

The task force work group has asked me to emphasize to you the importance of receiving your organization's views and comments. For this reason, we hope you will be able to provide us with this valuable assistance.

Thank you in advance for taking the time and making this effort.

Sincerely,

James M. Wright
Project Manager

Enclosures

QUESTIONS SENT TO REPRESENTATIVES OF GOVERNMENT AGENCIES AND PROFESSIONAL AND NONPROFIT ORGANIZATIONS

An Assessment of the Nation's Program
for Floodplain Management

<u>Questions for Reviewing "A Status Report on the Nation's Floodplain Management Activity"</u>

I. What is the significance of the status report information on loss reduction tools and strategies?

A. For each strategy and tool (Part IV, status report) which seeks to <u>reduce loss of human life and property</u>, please answer the following questions.

1. How well is the stated objective (reduce loss of life and property) being accomplished at the Federal, State, and local levels, and by the private sector?

2. What can be done at each level to improve its effectiveness?

3. Who should be responsible for carrying out this objective?

4. Are all the tools for flood loss reduction discussed in the status report being utilized to their fullest potential? Why?

5. In achieving reduction in loss of human life and property, are there conflicts with maintaining natural values? Can these conflicts be resolved? If so, how?

6. Do you have any other related comments or recommendations?

B. For each strategy and tool (Part IV, status report) which seeks to <u>maintain floodplain natural and beneficial values</u>, please answer the following questions.

1. How well is the stated objective being accomplished at the Federal, State, and local levels, including the private sector and by the private sector?

2. What can be done at each level to improve its effectiveness?

3. Who should be responsible for carrying out this objective?

4. Are all the tools for maintaining floodplain natural and beneficial values discussed in the status report being utilized to their fullest potential? Why?

QUESTIONS SENT TO REPRESENTATIVES OF GOVERNMENT AGENCIES AND PROFESSIONAL AND NONPROFIT ORGANIZATIONS
(Continued)

-2-

5. In achieving preservation or restoration of natural floodplain values, are there conflicts with flood loss reduction goals? Can these conflicts be resolved? If so, how?

6. Do you have any other related comments or recommendations?

II. What organizational structure and approach or combination of approaches at the Federal, State, and local levels do you think are necessary to accomplish the two broad floodplain management goals of reducing loss of life and property and maintaining natural values?

III. Considering the overall status of floodplain management as we come to the end of this decade and century, and the trends that have been discussed in the status report, what do you think is achievable as a goal or goals for floodplain management for the year 2000 and beyond?

IV. What one or two factors do you believe are the greatest impediments to the effective implementation of floodplain management?

V. What comments do you have on the quality of the status report?

Is information contained in the status report accurate and reasonably complete? Is there an adequate and appropriate balance in presentation of subjects and information? Does the report provide for a proper balance in discussing the strategies and tools for flood loss reduction and maintaining natural values?

If not, please indicate where corrections should be made or supplementary information included. Please provide this supplementary information if possible and indicate the source of the data or information.

VI. Please share any other comments or concerns of your organizations' members.

APPENDIX F:

"ACTION AGENDA FOR MANAGING THE NATION'S FLOODPLAINS"

October 17, 1989

(A Review of *A Status Report on the Nation's Floodplain Management Activity*, April 1989.)

Prepared by the National Review Committee:[1]

Raymond J. Burby
Gerald E. Galloway
James E. Goddard
James G. Gosselink
H. James Owen
Rutherford H. Platt
William E. Riebsame, Vice-Chair
John R. Sheaffer
French Wetmore
Gilbert F. White, Chair
Stanley M. Williams

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1 A National Review Committee consisting of prominent floodplain and natural resource management professionals was formed by the Federal Interagency Floodplain Management Task Force in 1989. The National Review Committee reviewed *A Status Report on the Nation's Floodplain Management Activity: An Interim Report*, April 1989, and provided detailed comments on the data and analysis contained in that report. The Committee also met to discuss the effectiveness of floodplain management in the Nation and prepared "An Action Agenda for Managing the Nation's Floodplains" (the Action Agenda).

The Action Agenda report, which is presented in its entirety in this appendix, contains the Review Committee's observations on the present floodplain management situation, the evolution of national floodplain management goals, and some key factors that affect the ability of governmental agencies and the private sector to improve floodplain management capabilities. The report ends with the Committee's recommendations for further actions that should be carried out by federal agencies to improve the current status of floodplain management.

Biographical sketches describing the qualifications of each member of the Review Committee are provided at the end of the Appendix.

ACTION AGENDA FOR MANAGING THE NATION'S FLOODPLAINS

Table of Contents

Preparation of both our detailed comments and this broader assessment was greatly facilitated by the staff of the Natural Hazards Research and Applications Information Center of the University of Colorado at Boulder, and by its project manager, Mary Fran Myers.

ACTION AGENDA FOR MANAGING THE NATION'S FLOODPLAINS

A report on the status of floodplain management in the United States provides a timely occasion to examine the effectiveness of those activities in recent years and the extent to which they are likely to meet the nation's needs in the years ahead. We have reviewed the interim Status Report on the Nation's Floodplain Management Activity and have offered a detailed set of comments on the data and analysis it contains. These comments have been transmitted to the Task Force and to L.R. Johnston Associates.

Based on review of that report and our experience with diverse aspects of floodplain problems, we call attention here to implications of the report for future public and private policy affecting the use of floodplains. We sum up the present situation, observe how the national aims of floodplain management have evolved and how Federal activities have moved toward them, and recommend further action required in light of current conditions and trends.

The test of how well the management activities are being carried out is in what happens at the level of individual farms, households, and local communities. We have assessed the wide-ranging efforts of Federal, State and Local agencies to support or guide actions at that level, and have sought to appraise the outcomes of those efforts as reflected in the natural and social environment of the nation's floodplains and related areas. This report sums up the Committee's assessment and recommends a series of actions that should be taken as soon as practicable at the Federal level.

At the outset it is important to recognize that in practice there is no truly unified national program for floodplain management. This stems in part from ambiguity in national goals. If the limited resources of money and people are to be effectively deployed, it will be necessary to clarify and harmonize the two major goals as they have come to be defined on the national scene and as they are discussed in the following pages.

In numerous instances the evidence provided by the Status report is insufficient to warrant a firm judgment as to the progress of floodplain management. In those cases we suggest steps that should be taken to provide a basis for sound evaluation. Lacking fully satisfactory data, we nevertheless have ventured provisional judgments as to what has been happening and as to what accounts for conspicuous successes and failures. Further data collection and analysis thereby may be spurred.

The present status of floodplain management does not encourage complacency. The record is mixed. There are encouraging trends, as with the number of communities having some form of floodplain regulations, but the rising toll of average annual flood losses has not been stopped or reversed. Some activities look more productive on paper than on the ground or in the real vulnerability of people. On balance, progress has been far short of what is desirable or possible, or what was envisaged at times when the current policies and activities were initiated.

The Situation in Brief

When the first Federal commitment to flood problems on a national scale took shape in 1936, the emphasis was heavily on protection of hazardous areas by flood control works in the floodplain or upstream. In 1966, a Presidential Order focused attention on a broader array of measures that could be practiced by Federal, State, and Local agencies to manage flood losses. During the late 60's and early 70's, with increasing environmental awareness and enactment of the NEPA and Clean Water legislation, additional attention was focused on protection of the natural values of floodplains. The possible Federal approaches were refined and expanded in A Unified National Program for Flood Plain Management in 1976, and further revised in 1979 and 1986, as described in the Status Report.

Despite massive public and private efforts to reduce flood vulnerability, losses to the nation from occupance of riverine and coastal areas subject to inundation are continuing to escalate in constant dollars. Some of the losses can be attributed to failure to complete protection works. Most can be attributed to increased property at risk. Vulnerable property clearly is expanding in extent and value. Losses include damages to properties and public infrastructure, disruption of local economies, disruption of traffic flows, and death and suffering for people living or caught in flooded areas. Average annual damages for the country as a whole are on the order of $2-6 billion (1985 dollars). This indicates that the statistics are notoriously incomplete and inaccurate. There has been little careful appraisal of benefits derived from use of floodplains, or of the proportion of losses and corrective expenditures that are plainly uneconomic.

When floodplains are developed for urban and agricultural purposes, the natural values they provide can be reduced. Data on the rate and quality of loss of these environmental assets are also poor. The continuing flood damages and losses stem from the ways floodplains are used. Private interests, in many instances, develop land to maximize the owner's economic return but in a fashion that degrades natural values and increases public expenditure for relief, rehabilitation, and corrective action. Government programs, however well intentioned, often encourage such adverse developments. The exceptions, however, where development enhances and preserves natural values, provide encouragement that it may be achieved more widely.

The current system for managing floodplains and protecting the nation from impacts of unwise use is piecemeal. It is dispersed among a variety of agencies at Federal, State, and Local levels. The <u>Unified National Program for Flood Plain Management</u> was intended to correct this. In order to address why that program has not succeeded and what now should be done, it is important to step back, and recognize and clarify the goals that have evolved.

Two Goals of National Floodplain Management

The goals now being pursued by the Nation in these matters are two-fold and inter-related, and often not easily harmonized.

1. **To reduce the vulnerability of all Americans to the danger and damage of floods.**

The dangers of flooding include threats to life, safety, public health, and mental well being as well as damages to properties and infrastructure, and disruptions of the economy. Protection from those hazards should be provided, by whatever measures are suitable, for floods of the 1%, or 100-year, frequency level as a minimum. Protection from the effects of greater, less frequent flooding is still needed in those places where such flooding will cause unacceptable or catastrophic damages.

2. **To preserve and enhance the natural values of the Nation's floodplains.**

Natural floodplains serve society with flood water storage, ground water recharge, water quality enhancement, aesthetic pleasure, and habitat for plants and animals. Many floodplains have cultural and historical significance. Urban and agricultural developments in floodplains may reduce those services with resulting costs to society for replacement or in degraded quality of life. It is in the public interest to avoid development that destroys those values or, in instances where the public good requires development, to assure that measures are taken to mitigate the loss in values by replacement or other means.

These two goals are achievable and can be reconciled through appropriate management shared by the agencies involved in ways that can be measured.

Assessment

The National Review Committee believes that:

- While considerable progress has been made over the past two decades, the Unified National Program is neither unified nor national. It falls short of achieving the goals set out for it by the Congress and previous administrations in several respects. It does not integrate adequately either the numerous program aims or the efforts of those charged with implementing them.

- Federal agencies have, in general, made efforts to focus on the immediate goals of their specific missions defined in legislation and administrative guidance, as outlined in the accompanying figure. They have, for the most part, been diligent and forward-looking within the bounds of their statutory charters. At the technical level, they have made major contributions to the Nation's ability to cope with flood hazards. The figure does not show the vast differences among agencies in how they foster local efforts. It does suggest the complexity faced by a local agency in trying to deal with diverse Federal programs.

FEDERAL AGENCY FLOODPLAIN MGMT. PROGRAMS	Department of Agriculture	Army Corps of Engineers	National Oceanic and Atmospheric Administration	Department of Health and Human Services	Environmental Protection Agency	Federal Emergency Management Agency	Department of Housing and Urban Development	Department of the Interior	Department of Transportation	Tennessee Valley Authority	Small Business Administration	National Science Foundation
Flood Hazard Studies/Reports	●	●				●		●		●		
Technical/Planning Assistance	●	●	●		●	●	●	●	●	●		
Structural Flood Control	●	●						●	●	●		
Warning and Forecasting			●							●		
Emergency Preparedness and Recovery	●	●		●		●	●		●		●	
Research	●	●	●		●	●		●				●
Nonstructural Flood Control	●	●			●	●				●		
Environmental Protection	●				●							
Water Quality Protection and Wetlands	●	●	●		●			●				
Protection of Endangered Species								●				

- There is no central direction for the Unified National Program. No agency has the charter or capability to carry it out in its entirety, and no agency has authority for assuring coordination of the numerous programs targeted on its objectives. There are serious overlaps, gaps, and conflicts among programs aimed at solving the same problem.

- Federal agencies, partly in response to budget reductions, have made significant advances in shifting operational responsibility for selected programs - involving either funding or regulations - to the State and Local level. Generally, the response of State and Local governments has been constructive, although its quality varies by State and region.
- Several indicators point to progress in floodplain management programs:
  - Participation in the National Flood Insurance Program (NFIP) has increased. Initial identification of flood hazards has been completed for over 18,200 communities now in the program, of which 16,400 have adopted some kind of management measures.
  - The NFIP no longer subsidizes insurance for new construction in the floodplain.
  - The new technologies and techniques associated with hydrologic forecasting, modeling, and flood warning have substantially improved the quality of those activities.
  - Considerable effort has been made to identify and protect wetlands within as well as outside floodplains.
- Federal agencies have been inconsistent in assimilating the concept of the natural value of floodplains. Their

mission statements are accordingly inconsistent. Full implementation of natural value protection is less widespread.

- Agency competition, duplication, and resulting inefficiency are fostered by the patchwork of Federal legislation giving differing authorities and directives.
- Responsibility at the Federal level for data collection is scattered among many agencies so that none take the lead in collecting, analyzing, and reporting on the full range of floodplain characteristics and management activities. As a result, it is impossible to accurately appraise the current status of floodplain management activities across the nation.
- The many Federal programs lack a common focus, and create conflicts and limitations that act as impediments to Local jurisdictions in implementing floodplain management.
- States and communities have had varying success at accepting and balancing the disparate elements of the Federal programs. Some states and most communities appear to lack the full resources necessary to bring about comprehensive local action without Federal support.
- Considerable infrastructure and many important Federal and local structures remain in the floodplain and,

although protected to a degree, remain vulnerable to large scale damage. Little information is available on the degree of vulnerability.

- While some states and communities have taken a comprehensive approach to floodplain management, others have not. This failure to integrate flood loss reduction, protection of natural values, and Federal and community development goals, hinders achievement of floodplain management objectives. In addition, because many problems may encompass larger hydrologic regions and may extend across several local jurisdictions and perhaps states, development of broad state and interstate plans may be necessary.

The detailed support for these assessments is to be found in the Status Report or in its lack of necessary information.

Factors Affecting Further Activity

As background for our recommendations, we note significant factors that may be expected to shape the ability of government and private sectors to improve floodplain management.

Much of the public action is constrained by prevailing perceptions, sometimes incorrect, of floods and their consequences. Flooding is rare in many areas, and generally is not regarded as an important issue in community policy making. People believe it won't happen again, or in their community. Although some kind of regulation of flood-prone land may be enacted, flood problems in most communities have low salience in the public budget. Local governments misjudge their ability to deal with severe overflows. Moreover, many people believe the best way to deal with a flood problem when it does seem crucial is to commit public funds to construction of a project to store or control flood waters. All this is reflected in budgets and in the interaction of public agencies and private developers.

Even where the public is well informed, the management effort is difficult and complicated. There are conflicting technical viewpoints in mapping the precise areas to be inundated by an event defined by a statistical probability, in making the results lucid for lay people, and in identifying and evaluating the whole set of natural features affected. There are complications in approaching a flood problem in the context of an entire drainage area, and in anticipating the consequences of a loss mitigation measure upon an area's economy and welfare.

The barriers to smooth implementation of a management effort are well known wherever a large number of agencies, each with its own statutory mission, seek their own ends. This is the case with floodplains. Administrative staffs defend their own turf and prefer sole responsibility for a project or program.

Floodplain managers at all levels of government have an uneven degree of knowledge about the diverse strategies and measures comprising floodplain management, for example, a combination of structural and non-structural measures. A variety of disciplines therefore are called into play, but there is no well-established institution to train floodplain managers.

Often, lack of familiarity with all of the available techniques biases the investigation and selection of solutions for specific flood problems, hinders the development of comprehensive floodplain management, and impedes balancing of the dual objectives of flood vulnerability reduction and natural values protection.

Beyond such direct constraints, there are a number of trends on the national scale that make floodplain management intricate and require flexible methods. We enumerate a selection of these.

- Aging public infrastructure (bridges, roads, water and sewer lines) will require replacement or upgrading during the coming decades. The strengthening or expansion of existing services in riverine and coastal flood hazard areas will require tough decisions at the local level as to whether and how further growth in those areas can be managed without increasing flood vulnerability.
- Existing small-scale development in numerous hazard areas is gradually being replaced by new forms and patterns. In coastal areas, for example, traditional seashore cottages are being replaced by higher density condominiums and commercial structures; whether this can be done while achieving the twin goals of reducing vulnerability to flood and erosion losses and protecting natural values remains to be seen. Some other areas where property is deteriorating due to

repeated flooding are being resettled by low income people.

- Improved water quality in some river reaches is attracting more recreational use of waterside lands.
- Floodplain management will increasingly be seen as an element in overall environmental protection and improvement. Floodplains will be viewed as integral landscape elements requiring special attention.
- The increasing scale and sophistication of urban development increase the potential for integrating floodplain considerations in the planning process but also enlarge the possibility for dramatic changes in vulnerability.
- The recent decades of regulatory efforts, along with urban growth, have resulted in and will continue to encourage dense development adjacent to regulatory boundaries. Such concentration of development may increase vulnerability to catastrophic losses from large floods.

Other technological and social trends are provided in the <u>Status Report</u>. The ones noted above are enough to suggest that the national program as a whole must be alert and flexible in dealing with new conditions as they arise.

Recommended Action

We recommend six groups of actions that should be taken by the Interagency Task Force or by other Federal agencies in close collaboration with State and Local organizations.

1. Integrate flood loss vulnerability and protection of floodplain natural values into broader state and community development and resource management processes.

   1.1 To promote integrated planning and management of appropriate hydrologic units, many of which encompass multiple local and state jurisdictions, the Interagency Task Force on Floodplain Management should vigorously foster the preparation of State floodplain management plans involving both public and private interests and, where appropriate, interstate agreements for preparation of basin plans. Such plans should consider and balance measures to preserve and enhance the ecological integrity of hydrologic units with measures to meet social needs.

   1.2 Because comprehensive floodplain management programs provide a means for balancing economic development, flood-loss reduction, environmental protection, and other community goals, along with means of integrating stormwater quality and quantity objectives with upland and floodplain land uses, sections 1361 and 1315 of the National Flood Insurance Act should be administered so as to require preparation of comprehensive floodplain management plans that complement the two national goals as a condition for continued participation in the National Flood Insurance Program. (Several of our members regard this requirement as impractical because many local governments lack the resources necessary to meet it.)

1.3 As a further incentive for the preparation of such plans, the Interagency Task Force should draft and recommend an Executive Order requiring that new Federal investments, regulations, grants-in-aid, and other floodplain actions be consistent with State and Local floodplain management plans insofar as they conform to Federal standards.

1.4 To assist in preparing comprehensive floodplain management plans, the Interagency Task Force should seek to coordinate Federal programs and to foster model plans, demonstration projects, and research to improve planning methods and techniques.

2. <u>Improve the data base for floodplain management.</u>

2.1 In jurisdictions expected to experience rapid rates of urban growth in upstream drainage areas, the floodplains should be re-mapped to take into account hydrologic conditions associated with full development of the drainage areas under existing land-use plans and policies of relevant jurisdictions, with a view to curbing increased stormwater runoff.

2.2 A cooperative and jointly funded program should be established by the National Science Foundation and the interested Federal agencies to develop methods for mapping, regulating, and identifying natural values in areas with special flood hazards including: 1) alluvial fans; 2) fluctuating lake levels; 3) ice jams; 4) moveable stream channels; 5) land subsidence; 6) storm drainage overflow and backup, and 7) mud flows, and to develop methods for measuring the flood storage capacity of river reaches.

2.3 The Interagency Task Force should formulate an accurate and affordable national system for gathering flood loss data meeting the needs of policy makers and floodplain managers.

2.4 The National Science Foundation should be requested to consider funding research to examine, in a selected sample of communities, the full benefits and costs, both public and private, of floodplain occupancy and associated floodplain management measures, having due regard for national productivity, the impacts on natural values, and the equitable distribution of costs and benefits.

3. <u>Give weight to local conditions</u>

3.1 Because uniform national prescription standards for the preservation, use, and development of floodplains and other hazard areas sometimes create the potential for inefficient allocation of resources and for social inequities, the Federal agencies should examine the practicability of using performance standards, implemented through local watershed and floodplain management programs, but should not promote any slackening of limits on permissible vulnerability.

3.2 The Federal Insurance Administration should adopt and implement a community rating system to encourage communities to adopt flood hazard mitigation measures particularly suited to their local circumstance. Such a system should recognize the need to reconcile loss reduction, public safety, and environmental objectives.

4. <u>Minimization of Conflicts among Federal Programs</u>

4.1 The Office of Management and Budget should establish an independent task force to further review the Status report's findings, and recommend those changes in the Federal structure and delegated legislative authority needed to insure execution of a sound Unified National Program for Floodplain Management.

5. <u>Reducing Vulnerability of Existing Buildings</u>

5.1 Because the vast majority of buildings and infrastructure presently exposed to flood damage will not be protected fully from flood waters by structural projects or nonstructural programs, other approaches are needed at both Federal and State levels. As a first step in addressing that problem, the Interagency Task Force should draft and recommend an Executive Order charging all Federal agencies with the preparation of assessments of the vulnerability to flooding of a sample of Federal facilities and those State and Local facilities constructed wholly or in part with Federal aid. The report should identify the facilities' expected average annual damages, estimate the costs of various protection measures, and extrapolate conclusions on the total Federal investment subject to flood damage. The report should be submitted to the President and the Congress with recommendations on appropriate programs to protect Federal facilities.

5.2 As an aid to coordination of those activities, the Interagency Task Force should report which agencies are undertaking nonstructural damage reduction activities and their funding levels.

5.3 Two approaches, in particular, deserve greater attention as viable damage reduction measures: flood preparedness and retrofitting (floodproofing). The National Science Foundation should be encouraged to fund research on the techniques, benefits, and costs of these approaches to identify their utility and impediments to their implementation.

6. <u>Improvement in Professional Skills and Public Education</u>

6.1 Inasmuch as the lack of personnel in Federal agencies and in State and Local government who are trained in the interdisciplinary field of floodplain management is an important constraint on progress in the implementation of comprehensive floodplain management, the Interagency Task Force should develop training programs and conduct regional training, at an affordable rate, of appropriate governmental personnel.

6.2 Recognizing that comprehensive floodplain management programs will be more successfully implemented if they are understood and supported by the general public, the Interagency Task Force and its member agencies should continue, expand, and evaluate efforts to inform and educate the public about the nature of flood hazards, the natural values of floodplains, and the various strategies and tools available for comprehensive floodplain management.

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Index[1]

[1] This index has been prepared to assist the reader with references to the Introduction, 16 chapters, and Epilogue of the *Assessment Report*. The index does not include references to the Appendices. Users of the *Assessment Report* should note that the index may not include every reference to the subjects listed, and that some subjects or topics of interest to the reader may not be included in the index.

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