Flood Hazard Management in Government and the Private Sector

Proceedings of the Ninth Annual Conference of the Association of State Floodplain Managers

New Orleans, Louisiana
April 29-May 3, 1985

Association of State Floodplain Managers

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Flood Hazard Management in Government and the Private Sector

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The opinions contained herein are those of the authors and do not necessarily represent those of the funding or sponsoring agencies or organizations, or those of the Association of State Floodplain Managers.

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PREFACE

"Flood Hazard Management in Government and the Private Sector--Where Are We?" was the theme of the Ninth Annual Conference of the Association of State Floodplain Managers, held in New Orleans in May of 1985. Flood hazards reviewed included riverine, coastal, alluvial channels, ice jams, and various human-caused problems. Activities to manage those hazards involve mapping, regulation, mitigation, warning systems, and public education. The private sector was represented by consultants, developers, the insurance industry, the news media, financial institutions, and the legal profession.

The conference provided an excellent opportunity to learn of the latest developments in flood hazard management. These proceedings contain information that will be most helpful in continuing governmental and private efforts to prevent and reduce flood damages. For those unable to attend the conference, and even for those who were there, this volume will be a valuable reference work.

The Association of State Floodplain Managers hosts a national technical conference annually, and sponsors other smaller meetings throughout the year. Through these meetings and our other activities--designing training programs, conducting research, a bi-monthly newsletter, and technical committee projects--we strive to provide our members and anyone interested in managing flood hazard areas with the latest, most useful information.

French Wetmore, Chair
Association of State Floodplain Managers
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Our special thanks to Secretary Dorothy Taylor of the Louisiana Department of Urban and Community Affairs and to Wes Steiner of the Arizona Department of Water Resources for allowing our schedules to shift to meet conference deadlines. Susan Kelly, Dan Hawkins, and Ed Koch of the Louisiana Floodplain Management Section did an outstanding job of planning and handling the multitude of small but essential details of a national conference. We especially want to thank Jake Mullican and the Louisiana Floodplain Management Association for their contributions to, and participation in, the conference.

Of course, the speakers make the conference, and those at the New Orleans meeting did an excellent job of preparation and presentation. The Association extends warm thanks to all of them and their employers.

Many other individuals and organizations provided ideas, time, and money to ensure the success of the conference, and they are remembered with gratitude if not specifically mentioned here.

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KEYNOTE ADDRESS
When one is invited to keynote a conference, one should create a mood, create a focus. But since you are experts, with ideas and conviction, I'll leave the discussion of floodplain management for the presenters. You will be hearing an excellent group of papers, some looking back, some looking forward. I would like to talk about how we as an association might adjust our activities to be even more effective in the next decade. I hope this will be a popular topic of conversation for all of you this week, and that you will determine a process for the Association to use in organizing itself for the next ten years.

I will 1) provide you with my observations about the national and local scene, 2) describe the trends I see, and 3) offer a series of initiatives that I recommend your association adopt as its core program for the next ten years. Some changes will be required by events beyond our control. Some we can control. The roots of this organization are in a program that is changing. There is reason to believe those changes will affect us. I will talk quite generally. All of you may not agree.

I want to represent the local community. At the local level we: develop zoning, approve subdivisions, and require floodproofing. We are the people who caused the problem we're trying to solve. We are the people who will solve it!

Let me explain to you my biases:

- I am a strong advocate of floodplain management and the National Flood Insurance Program.
- I have been involved for years in the federal program at the local government level and as a consultant.
- I am presently involved in planning flood control solutions for over 200 square miles of land in five states. All have substantial hazards.
I believe the best local programs and the worst local programs are the result of local attitudes and interest, not federal or state regulations.

I believe that a little bit of excellence is preferable to a lot of mediocrity.

I have a Western perspective.

Let's start with my learning something about you. I need a show of hands.

1) How many of you are from east of the Mississippi? 50%
   West of the Mississippi? 50%
2) How many are here for the first time? Many. Good!
3) How many of you feel there is a need for added federal support for the floodplain management programs? Many.
4) How many of you feel the national debt might affect your Association's future? A few!

Trends

Today we are in a period of major change. This is not a political comment. It is derived by being attentive to available information. The 50's, 60's, and 70's were different periods, but as we look at the 30-year period, we can see some very clear trends in our country.

- Growth ethic has lessened.
- Environmental concerns have heightened.
- Public works have yielded to social works or "quality of life" issues.
- Public support for programs is harder to obtain.
- Our standard of living is not increasing. It is probably decreasing.
- Social programs have increased.
- Our basic industries, steel and agriculture, are in serious trouble.
- Our service industries are increasing.
- Our banking system is having difficulties.
- Oil and its price were controlled outside the United States, and we were in lines at gas stations.
- Inflation rates around the world are nearly out of control, even in Israel, a western-thinking country.
• We have seen a blizzard of legislation at all levels affecting our lives and making our jobs more difficult.
• We are internationalized in trade, our dollar, and basic resources.
• Global unrest has increased, including that in Central America.
• There has been major growth in U.S. government and centralization of decision making.

As a nation we are in debt. Our national debt is growing at a rate of $200 billion a year. Our balance of payments deficit exceeds $100 billion annually. This, our third year of recovery, has still left many segments of the economy and areas of the U.S. in near-depressions. We have loaned billions of dollars to other countries that have no way to repay it. The interest on the national debt is fast becoming the major budget item. The programs that we started or expanded during the last 20 years have now exceeded our ability to pay for them. The next ten years will be a period of program cuts after severe competition by advocates. There will be less and less federal funding of public works type programs. Flood insurance and other social programs will be reduced slowly.

The Association and its Future

If the Association plans to organize itself to become a stronger advocate for federal funding and to become a stronger voice in federal policy, it will 1) find itself competing with very powerful social programs, 2) find that the strategies of the last 20 years for dealing with the federal government don't work, 3) find it doesn't have a constituency, and 4) find that new, expanded programs will not be funded. The development of land is continuing. The reduction of hazards to existing homes and businesses is continuing at the local level. Local people see quite clearly that federal financing for projects is reduced and delayed and are slowly turning back toward home-grown solutions. In short, the federal government will be a smaller not larger player. The weakness in the NFIP will not be fixed. We must fix it at the state and local level.

Local government and those developing land need thoughtful solutions and our help more than ever. In spite of what may sound like a bleak future, this Association now has an opportunity to become the major force for improved floodplain management throughout the country. My initiatives can get you started. My initiatives for the Association recognize the reality of future
federal funding and the use of good management principals. They are the basis for the next stage of the implementation of successful floodplain management.

Initiatives

1) Build your organization, its structure and its objectives around helping local floodplain managers. Make it downward-service oriented.

2) Find and support programs that are master-planned solutions to floodplains in each locality.

3) Establish local or regional studies, workshops, and seminars that stress master-planned solutions and successful models to be copied.

4) Involve yourselves in local decisions on behalf of good floodplain management practices. Include planning commissions, city councils, and boards of supervisors.

5) Use each disaster as an opportunity to improve local regulations. Move in, help, and lobby.

6) Review local disaster relief requests and comment on justification for relief and mitigation provisions. Be prepared to oppose inappropriate applications.

7) Encourage master-planning! Other solutions are only temporary or confusing to locals

8) Develop unique solutions for unique regional problems and publicize. Publish standards.

9) Focus your energy on communities that want your assistance.

10) Actively involve the private sector. Owners and developers are allies of good programs, have dollars to help you, and have political strength.

11) Establish competition in each state or region for innovative programs and publicize! Publish the results!

12) Focus your attention on creating a few examples of excellence. Provide leadership.

13) Consider organizing around regional issues rather than by states.

Local government and developers want master-planned solutions that they can understand. Sell those to them! They also want real life solutions that apply in a cost-effective way. They would contribute to regional solutions if
they understood them. They must consider, as is appropriate, both structural and nonstructural solutions, and so should we.

I strongly recommend your Association observe the trends and adopt a "grass roots service" program. Team with, but be less dependent on, the federal government. You have the intellectual resources to provide excellence at the local level. The federal government needs your help. Quality floodplain management in this country will take some courage and some redirection, but it will be very rewarding. I stand available to help.

Thank you.
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PART ONE
ASPECTS OF FLOOD HAZARD REDUCTION
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STATUS OF FLOODPLAIN MANAGEMENT AMONG FEDERAL AGENCIES

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My assignment today is to review the status of floodplain management among federal agencies. At first glance, it is a very discouraging task. The Tennessee Valley Authority's (TVA) proposed FY 1986 budget is zero. The Soil Conservation Service's (SCS) proposed budget is sharply cut back. The Federal Emergency Management Agency's (FEMA) proposed budget cuts the number of regional offices from ten to six. In short, the federal floodplain management effort seems to be in trouble.

However, the proposed budgets do not provide an adequate context in which to view federal floodplain management activity. Therefore, I will first review progress made during the last 20 years, and then discuss the FY 1985 budgets and personnel levels.

Progress Since 1965

In 1965 it became apparent that the costs of various flood control programs were continuing to rise. Disaster assistance payments were also accelerating. Additionally, the extent of the flood hazard itself was poorly identified. All this led the Executive Office of the President to establish a task force of nine experts to examine the status of floodplain management in the U.S. The task force found a variety of problems, in particular, inadequate consideration of nonstructural measures for mitigating flood losses. The task force declared the need for a unified national program for floodplain management, and set out five goals: 1) to improve basic knowledge about the 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; and 5) to adjust flood control policy to sound criteria and changing needs.

The task force also recommended ways to achieve each of the goals. Four of the recommendations addressed the goal of improving our basic knowledge about flood and flood hazards. The first one—to define and outline the flood hazard--has led to a federal expenditure of almost $700 million, and resulted
in the publication of flood hazard boundary maps for more than 18,000 communities, including more than 7,500 with detailed flood hazard studies. The second recommendation—determination of flood frequencies—has led to federal agency adoption and application of a uniform technique for determining flood flow frequencies in flood hazard studies. The third suggestion that a national program be established to collect more useful flood damage data has prompted considerable discussion but little action. The fourth recommendation—to establish a program of research on floodplain occupancy and hydrology—has been realized in part through several national efforts.

Another four recommendations addressed the goal of improving coordination and planning for new floodplain development. The first of these—specify criteria for using flood information and encourage state coordination of floodplain regulation—has been met by the adoption of the 100-year base flood standard and its use by all states in the regulation and management of floodplains. The second recommendation—assure that state and local planning take proper account of flood hazard—has been realized in large measure through the requirements of the National Flood Insurance Act, which prohibit federal assistance to those communities with identified flood hazards that refuse to regulate land use. The third suggestion was to give more consideration to relocation and floodproofing as alternatives to repetitive construction in floodplains; this is followed in the requirements of the hazard mitigation team program, and through limitations on the amount of casualty losses that can be claimed as federal income tax deductions. The fourth directive called for an executive order that all federal agencies consider the flood hazard in their actions and facility siting; Executive Order 11988 was just such an order.

Two recommendations addressed the goal of providing technical services to managers of floodplain property. The first one called for the establishment of programs to disseminate information and provide technical assistance on alternative methods for reducing losses; it has been met through new and strengthened federal and state programs to provide studies and technical assistance, and by publication of numerous handbooks and guidance documents. The second recommendation—improvement of a national flood forecasting system—has been accomplished in part by improved data collection and communication systems and flood forecasting models.

A single recommendation addressed the goal of moving toward a practical national program for flood insurance by calling for an insurance feasibility
study. This led to the passage of the National Flood Insurance Act in 1968; currently, 17,500 communities participate and there are 1.9 million insured properties.

Five recommendations addressed the goal of adjusting federal flood control policy to sound criteria and changing needs. The first one--broaden federal flood control authority--has been carried out in part by administrative procedures requiring evaluation of alternative plans and nonstructural plans. The second recommendation--modify federal cost-sharing requirements--has been the subject of extensive studies, but basic differences between the Congress and the Administration remain. The third suggestion to report flood control benefits in the future distinct from benefits to existing property caused there to be administrative procedures that specify benefit classes and cost-allocation procedures. The fourth recommendation--give authority to include land acquisition as part of federal flood control plans--has been met in part through individual project authorizations and the National Flood Insurance Act's authority to permit purchase of insured, severely damaged properties. The last recommendation was to broaden the loan authority to allow local contributions to flood control projects, but that has been rendered invalid by revenue-sharing and block grant programs.

Twenty years later, the task force report must be regarded as a powerful catalyst and a benchmark for major advances in the nation's efforts to reduce flood losses. Because of the task force report, the intensive development of the nation's floodplains during the last 20 years has been accompanied by a growing number of flood loss mitigation actions.

Today, among the federal agencies there is conceptual concurrence on a framework for floodplain management, common hazard identification standards, consistency of flood hazard evaluation procedures, and the need for cooperation among the federal agencies. There are now interagency agreements, an interagency floodplain management task force, a floodplain management coordinator in each state, and skilled state floodplain management staffs in many states to carry out extensive programs. The existence of a strong and active Association of State Floodplain Managers testifies to the new role of the states.

Levels of Federal Activity

With this background, let us look at the current federal picture as sketched by FY 1985-1986 budgets and full-time staff equivalents for the ten
agencies on the Federal Interagency Floodplain Management Task Force. Data are based on best estimates and on some budget information. In 1985, 730 full-time staff equivalents and $83.3 million were allocated to activities directly involved with floodplain management. In 1986, 672 full-time staff equivalents and $82.7 million are projected for the same activities.

Full-time equivalent staff shows an apparent net decline of 58, or 8%. This reflects projected elimination of the entire TVA staff of 33, and reduction of 38 SCS staff as the first step toward program termination in 1987. Partially offsetting is projected increase of ten staff by the Corps of Engineers and three by the Department of Housing and Urban Development. Staff levels of the other agencies are unchanged.

The FY 1985-1986 apparent reduction in available funds of $6 million, or less than 1%, is deceptively small. It represents elimination of $1.95 million in TVA funds and a negligible amount of SCS monies, offset by a $1.4 million increase in Corps funds. A precipitous decline in SCS funds will not appear until 1987 because of the multiyear nature of ongoing projects. Other agency funding is unchanged.
STATUS OF STATE FLOOD HAZARD MANAGEMENT PROGRAMS

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Introduction

States have been active in flood hazard management programs for over 20 years. Within that time period, there have been significant changes in the quality and sophistication of state programs. State programs have gone from requiring zoning only, to many other forms of flood hazard management. Over 35 states require direct regulation of the flood hazard area by local or state government. Each one of the states, the District of Columbia, and the territories of Puerto Rico, Guam, and the Virgin Islands have a designated coordinator for the National Flood Insurance Program. The number of state employees working on flood damage reduction has increased between 50 and 100 full-time equivalents since 1979 (Larson, 1983).

State Program Content

Regulations

Some of the early state programs involved direct state regulation of the floodplain, or at least the floodway. Floodfringe development was generally left to local regulation. As more and more states adopted legislation, however, they realized that regulation through land use zoning provided the best opportunity for preventing future flood damages. As with most land use regulatory programs, it is not a popular issue with most local governments. For those reasons, state oversight and minimum state standards are considered essential.

The state standards generally provide for no structures (open space use only) in the floodway where obstructions could cause increased flood elevations on other property owners upstream. The federal standard allows an obstruction to increase flood elevations up to 1.0 foot. However, more and more states are requiring small or zero increases in flood elevation due to obstructions in the floodway (New Jersey, Maryland, Iowa and Wisconsin allow essentially zero increase). Compensation for property owners for flood increases, or actions to compensate for the increase are options to handle the "taking without just compensation" issue.
Engineering and Mapping Assistance

Well over a dozen states have developed hydrologic and hydraulic engineering capabilities. This includes performing full blown engineering studies to identify flood hazard areas. States tend to do studies in communities where the Federal Emergency Management Agency will not be doing a Flood Insurance Study. This may mean the Flood Insurance Study is not scheduled at all, or that one could not be done in a quick enough time frame to be in place before significant development would occur, since flood insurance studies generally take at least five years. It could also be a case where the existing study is incorrect or needs updating, which was discovered when a local community reviewed local permit applications.

States also perform case-by-case engineering analyses for local communities to determine floodway location and flood elevation. This occurs in areas where no study exists or where the Flood Insurance Study has identified only a general flood hazard area but provides no detailed engineering data. Some states will provide that calculation at no cost to single family property owners, whereas such case-by-case studies will be done by consultants for commercial ventures, as a cost of doing business.

In addition to actual engineering calculations, a number of states provide mapping assistance. This may be the actual production of flood hazard maps as part of an engineering study done by the state, or others, or it may involve review and revision of existing maps at the request of locals. Mapping errors are usually discovered when someone applies for a permit or the community has some reason to utilize the existing maps. Often the state will develop adequate data and submit it to FEMA for correction of flood insurance and regulatory maps.

Technical Assistance

Flood hazard management involves more than regulations. Accordingly, states provide technical assistance to local communities to develop and implement many such elements. Technical assistance to local communities is a key role for states. It is unquestionably an activity they are better able to provide than nearly any level of government. There are logical reasons for this: states are
closer to local communities than federal agencies so they can not only get to the community easier, but get to know community officials on a one-to-one basis. Communities are more inclined to call and trust someone they know and see often. The state person also has the advantage of being able to integrate the floodplain management programs with other related state programs such as septic tanks, wetland shoreland, subdivision and erosion control regulations, water supply and waste treatment programs, and many others. This results in the state person becoming a valuable resource person for the local community.

There are over 17,000 flood prone communities in the nation. Many of them are smaller communities with part time or volunteer staff with no technical background. They need assistance to help them review and interpret maps, develop adopt and administer ordinances and to act properly on permits appeals and variances. In the National Flood Insurance Program (NFIP) the requirement to zone is federally mandated in order to get flood insurance benefits. However, the legal mechanism and authority to zone is given to the community under state law. This means that legal procedures are different from state to state and must be tailored to the state law, an ability which state agencies best possess.

States have filled this need very well. Most of them have developed model flood hazard ordinances, attend meetings, hold training sessions and respond to day-to-day requests for technical assistance from local communities.

Flood Hazard Mitigation

Flood hazard mitigation is becoming increasingly important. Floodplain regulations are really effective only in reducing flood damages to future construction. Very few existing structure will ever be replaced or brought up to flood protection standards through the regulatory process. As a result flood losses will continue to those structures. Mitigation efforts are needed to flood proof, relocate or to provide warning, evacuation etc.

Historically, federal assistance has produced structural projects such as dams, levees, etc., to protect existing structures. Despite over $14 billion in federal expenditures in the past 40 years, flood damages in the nation continue to increase.
Only in few rare cases have federal programs provided planning and implementation assistance for non-structural approaches to mitigation. States are beginning to fill this void. Maryland's watershed program and Louisiana's statewide Flood Control Program which provides flood hazard mitigation cost sharing, are excellent examples. Other states legislatures such as Minnesota, are considering enacting cost sharing programs for these efforts. The required mitigation plans following a presidential declaration are also providing in an impetus for passage of funding programs in Connecticut, California and Utah.

Related Resource Programs

Comprehensive programs or related resource protection programs provide excellent flood loss reduction at the state level. Examples are Michigan's scenic rivers protection act and shoreland programs and Maryland's watershed program that requires comprehensive planning and cost sharing if local communities commit to the watershed plans for existing and future development and runoff conditions. Also, the wetland protection programs in New York, Maryland, Maine, Florida and Wisconsin and others prohibit most any development in the wetlands. Since nearly all wetlands are in the floodplain, this provides automatic flood hazard protection and prevents future increases in flood elevation.

States play a key role in tailoring local programs to local needs and conditions. For example, federal programs to study and map flood hazard areas are generally based on technology that can apply to a variety of flooding conditions. This may be inadequate in certain high risk areas such as alluvial fans, ice jams, areas below dams, etc. A few communities, usually with the assistance from states, are addressing ways to better manage these high risk areas. States, through the Association of State Floodplain Managers are working with federal agencies to improve study standards, mapping and development standards in these areas in order to reduce flood losses.
How States Can Improve Flood Loss Reduction Programs

While states have made significant progress, especially in the last five years, there is much yet to be done. The key state role is to assist locals in managing flood hazard areas. A review of existing successful state programs and their impact on improving local programs suggest some ways other states can improve. This would include:

1) Adopt legislation requiring local regulation of flood hazard areas. An increased state regulatory role in land use is very important (Burby, 1983).

2) Develop a diversity of state staffs that includes planning and engineering professionals in order to provide a broad array of technical assistance to local communities.

3) Provide the key state agency with authority for more than oversight of regulatory standards. This could include authority for assisting in flood warning, mitigation and other key floodplain management programs.

4) Insure that all state related programs such as sub-division regulations, highways, state facilities, wastewater treatment facilities and state funding programs, incorporate and address flood hazard management concerns early in the process. This can usually be done effectively through a state executive order.

5) Develop a data base to help states set priorities for efforts which will be most effective in reducing flood losses. This would include data on the number of structures in the floodway and the flood fringe of each community in the state, data that would indicate where future development will occur, and ongoing collection of hydrologic data for refinement of studies.

6) The cost of mapping and research by federal agencies should continue in order to free states to provide the most effective and efficient tools in their bag of tricks, that of providing technical assistance to locals.
Studies indicate that local programs are more likely to be effective where there are effective state programs. A review the programs around the nation leads to the conclusion that building state capability, getting states to assist each other and improving that capability and tailoring flood hazard management programs for delivery through the states to the locals will most effectively reduce flood losses in the nation and protect the life, health and property of the nation's citizens. Each level of government must contribute in the way it can be most effective toward this overall effort. The pivotal role of the state is a key essential element.

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Larson, L.
Sixteen years have passed since passage of the National Flood Insurance Act in 1968 spurred a massive increase in local flood hazard reduction programs. During that period, we've witnessed a revolution in local floodplain management and a reduction in the rate of increase in flood losses. Having said that, however, I think that most would also agree that we have a long way to go before we get on top of flooding as a serious national, state, and community problem. In this paper, I will briefly review what local governments are doing to reduce flood hazards and then look at how effective those efforts have been in terms of achieving private sector compliance with flood hazard management objectives. The paper concludes by identifying those states where compliance is most advanced, indicting how those states differ from states where private sector compliance with flood hazard management objectives is less complete, and suggesting what states and localities should do next about community flooding problems.

Local Flood Hazard Reduction Programs

Local flood hazard management programs are designed to reduce flood damages to existing development at risk and to minimize the risk of flooding to new development locating in flood-hazard areas. In order to reduce flood damages to existing development, communities have two choices: keep flood waters away from structures and people at risk or move the structures and people out of the way of flood waters. The first approach is very popular. About 70% of the flood-prone communities in the U.S. have in place some sort of engineering solution (e.g., channel improvements and dikes and levees) to their flooding problems. Those structures, however, usually do not solve the problem entirely. Our research suggests two reasons: communities with structural protection in place have a higher rate of new floodplain development than communities without structural protection, but in many cases those structures do not provide protection against flooding from very large (and very rare) storm events. The second approach to
dealing with flood losses to existing structures—moving buildings and people out of the way of the flood waters—is more effective than the first approach, but it is rarely used. Recent national surveys we've conducted indicate that only 2% to 3% of the flood-prone communities in the U.S. have relocated buildings from flood hazard areas.

In addition to preventing damages to existing development, local flood hazard management programs seek to prevent losses to new construction, either by guiding that development away from flood-prone areas or by requiring that buildings locating in the floodplain be elevated and/or floodproofed so that they are reasonably free of flooding. Our research indicates that localities are much more likely to use the second approach than the first. Most communities in the National Flood Insurance Program have adopted new ordinances or amended their existing development codes (zoning and subdivision regulations) so that, if properly enforced, new construction in flood-prone areas will be free of damage from most flood events. Communities are much less likely, however, to have done anything to keep new development from locating in flood hazard areas. About two of every five flood-prone communities in the U.S. have adopted floodway regulations, but less than one in five have taken steps to minimize development of the floodway fringe through land use regulation, land acquisition, preferential taxation, or capital improvements policies designed to minimize the attractiveness of flood-prone areas for development.

The amount of attention communities pay to floodplain management varies depending upon who is in charge of the local program. Across the nation, we found responsibility for floodplain management distributed as follows. The chief executive is in charge of the program in a quarter of the localities; the building inspector in a quarter of the localities; the planning director in about a fifth; the public works director or city engineer in about a fifth; and in the remaining tenth of the communities' programs are run by a variety of persons, such as the town clerk, city council, planning board, or a regional agency. Contrary to what most people might expect, the best programs aren't found where the chief administrator is in charge; in fact, those tend to be the programs with the lowest priority, fewest flood control and land use management measures in place, and programs that are not rated as very effective. Instead, localities pay the most attention to floodplain management when either the planning department or public works department runs the program. Where planners are in charge, programs tend to focus on
land use management measures; where public works is in charge, programs tend to focus more on flood control, but in both cases programs tend to be more fully developed than in localities where floodplain management is directed by the chief administrator or city council or where program responsibilities have been assigned to the building inspector, planning board, or some other group.

**Program Effectiveness**

Given the floodplain management measures localities have adopted and who's in charge, how good a job are localities doing with floodplain management? We tried to gauge that in three ways: 1) by the amount of new construction occurring in flood hazard areas; 2) by local program officials' and state officials' judgments about how well programs are achieving flood management objectives; and 3) by the extent to which property owners are complying with what we call "best management practices" for floodplain development. Here is what we found in a national survey of over 900 flood-prone localities conducted in 1983.

**Preventing Encroachment on Flood Hazard Areas**

Of 956 communities we surveyed in 1983, 65% had issued no building permits for floodplain development during the preceding year. Across all 956 communities, 94% of the building permits they issued during 1982 were for construction located outside of designated flood hazard areas; 6% of those permits were for construction located in an area subject to flooding (in coastal communities that figure rose to 18% of all new development). Since we do not have data on the proportion of those communities located in the floodplain, it is difficult to say whether, on average, flood hazard areas are receiving a greater or lesser proportion of new development than would occur in those locations by chance. In general, however, it does not appear that local floodplain management programs are having much effect on where new construction occurs in a community.

**Officials' Perceptions of Program Effectiveness**

When local officials were asked to evaluate the effectiveness of their floodplain management programs, about half rated their programs as very effective in preventing flood damage to new construction occurring in areas subject to flooding; about a third rated their programs as very effective in preserving the natural
values (flood storage, aquifer recharge, etc.) of flood hazard areas; and less than a third rated their programs as very effective in reducing flood damages to existing structures or public property. When state officials were asked the same question, they were about half as likely as local officials to rate local floodplain management programs as very effective in achieving any of those objectives. From either a state or local perspective, however, there is obviously room for improvement in the performance of local floodplain management programs.

**Property Owner Compliance with Best Management Practices**

In addition to asking local officials about overall program performance, we also asked them how well property owners in their jurisdictions were complying with what we term "best management practices" for development of flood hazard areas: elevating structures above the level of the 100-year flood; avoiding fill and other obstructions of the floodway; installing adequate storm drainage systems in new subdivisions and other development; and floodproofing existing structures. If we rate compliance as good when over half of the property owners are complying with those best management practices, then here is what we found. In two thirds of our national sample of communities, compliance with elevation and floodway fill practices is good; compliance with storm drainage practices is good in about half of the communities; and compliance with floodproofing practices is good in about a quarter of the communities. Again, there seems to be room for improvement at the local level.

**High Compliance States**

The top ten states in terms of local officials' ratings of property owner compliance with the four best management practices for development in flood hazard areas are, in order: Illinois, Hawaii, Minnesota, Rhode Island, Michigan, New Jersey, Washington, Virginia, South Carolina, and Nebraska. How do those and other high-ranking states' flood management programs differ from states where property owner compliance is not rated as well? To find out, we gathered data from the states about their flood management programs and combined those data with information obtained from our national sample of local governments. Here is what we found.
Thirteen of the factors we looked at seem to have a significant effect on property owner compliance. In order of the magnitude of that effect, they are: 1) scope of local government floodplain management programs in a state; 2) scope of state flood hazard information and education programs; 3) percent of the population in a state living in communities in the regular phase of the National Flood Insurance Program; 4) degree to which state program goals emphasize environmental protection as well as property damage abatement; 5) degree of state officials' contact with local government officials; 6) percent of a state's population living in metropolitan areas; 7) degree to which local officials are satisfied with technical assistance received from federal agencies; 8) degree to which flood-free sites for new development are available within a state's flood-prone localities; 9) absence of Corps of Engineers expenditures on new works in a state during the period 1978-1982; 10) number of state personnel working in flood hazard management programs; 11) presence of a "moralist" political culture in a state (people in the state tend to value positive governmental action in the public interest); 12) scope of state floodplain regulations; and 13) extent to which flood hazard management is a priority interest of the governor. Overall, those thirteen factors explain about 40% of the variation from state to state in property owner compliance with floodplain best management practices.

Next Steps

To conclude, I'd like to suggest where I think local floodplain management programs should be heading, based upon the results of our research at the University of North Carolina at Chapel Hill conducted over the past decade. To start, we need to think of ways of getting floodplain management onto local political agendas more often than we have in the past. States can help with that in a number of ways. They can work to increase local officials' awareness of the flood problem. They can work at the state level to link floodplain management to other program objectives; for example, the U.S. Environmental Protection Agency's recent move to require states to regulate major nonpoint sources of pollution, such as large shopping centers, should create opportunities to combine water quality and flood management objectives in state and local stormwater management programs. Finally, states can use various carrots and sticks to get local governments to think more
seriously about flooding. Our research indicates that state regulatory programs, for example, are effective not only because of their direct effects on property owners but also because of their indirect effects in persuading localities to give floodplain management more attention than they otherwise would.

Once floodplain management gets on the local political agenda, our research suggests that local programs are more effective when localities use multiple methods to achieve their objectives for flood hazard areas. Thus, we've found that while local regulations are a necessary first step in floodplain management, local programs should also encompass, depending upon local circumstances, flood control measures, watershed treatment measures, land acquisition, flood warning, and other local activities that will reduce the potential for flood losses and environmental damage. Furthermore, those multiple measures will likely work together better if they are formulated as components of a local floodplain management plan.

We also think that localities should be paying more attention to various innovative techniques for floodplain management. We believe the "cutting edge" of floodplain management at the local level will include the establishment of various exactions on new private development in flood hazard areas so that such development starts paying the full costs associated with a flood-prone location. Revenues raised through such exactions can be set aside in a fund earmarked for reconstructing public infrastructure damaged as a result of flood events. We also think that localities also need to begin paying more attention to stormwater management than they have in the past. Finally, we expect to see a number of innovative land use management techniques, such as transfer of development rights, applied to floodplain management.

State governments are in position to help localities with all of the "next steps" I've outlined here. We've made tremendous progress in floodplain management at the local level over the past two decades. With continued and expanded efforts at the state level, that progress should continue.

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THE CONNECTICUT COASTAL HOMEOWNERS’ FLOOD PREPAREDNESS PROGRAM

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Introduction

The Coastal Homeowners’ Flood Preparedness Program (CHFPP) brings municipal flood information to potentially vulnerable coastal homeowners, and it is delivered to them in their homes.

As the pilot program was being developed, we realized that there was no significant funding or staff time set aside. There was no allotment for it in the various departmental work plans, and the more thought we gave it, the more unclear it became where the responsibility for it should lie. Possibly our Coastal Management staff or Water Resources staff should have led the way, or maybe the Office of Civil Preparedness or the towns themselves should have, and what about Federal Emergency Management Agency (FEMA)? The Department of Environmental Protection had no authorization to take responsibility, but it seemed to be the logical next step to accompany the flood information we had on hand. Ultimately, we took charge.

We spread the information because the residents do not know about flooding, and because their lack of knowledge results every year in deaths. Flooding also has huge monetary repercussions at every level of government. Unfortunately, when all of the NFIP rate maps (FIRMs) are drawn and the Flood Insurance Studies (FIS) are in order, the information leaves the federal ranks and begins to trickle down through the system. It gets to the state level and then down to the municipality, but the trickle usually ends before the information gets to those who need it most to protect themselves—the homeowners. The whole reason for these programs was the vulnerable position of the homeowner, who frequently never sees the work that has been done regarding his or her actual homesite.

Program Goals

Our intent was to inform the participants of the nature of the coastal processes, the formation and intensities of coastal storms, the probable
coastal effects, and the best ways to combat individual loss. The first major goal of the program was to structure it so that each individual would know exactly what the next hurricane would do to his or her home. We wanted them to ask, "How can I protect myself from the possible loss when the hurricane comes?"

The second main goal was to advance the program with no misunderstanding of our intent. We did not want homeowners to think we were big government coming in to tell them what to do, or worse, suggesting that we wanted to take their homes. We tried to emphasize the effects of the natural processes. For example, the movement of one spit along the Connecticut coast has been charted for the last 130 years or so. In one 111-year period of time, the littoral movement and erosional actions, on both the spit and the attached shoreline, combined to produce a net land loss of approximately 40 acres. The emphasis was that the coast is not static and as residents they have good reason for long-term concern.

**Groundwork**

The groundwork for this program was laid over the course of two summers. In 1982 an inventory was taken of all the structures in the A-, B- and V-zones of Connecticut’s 25 coastal communities. The boundaries of the flood zones on the FIRMs were transposed onto the aerial photographs and the structures tallied. The results showed 3,941 structures in the V-zones and 19,099 in the A-zones, representing about 57,600 residents.

In 1983, as part of a public information project, a questionnaire was sent out regarding coastal flooding. The results showed that 87% of the people who now live at the coast did not live there when we had our last hurricane in 1955. Ninety-eight percent were the owners of the homes they lived in, and about 75% of those that answered were not aware of any type of municipal flood mitigation or preparedness programs.

**Location of Presentation**

The first step was to locate the chief elected official of the town, the beach association president, and a home in which to make a presentation to all property owners. The desired location for the presentation was the living room of a flood-prone home, in order to keep the presentation on a personal level with a small group (15-20 people). The first meeting was held in a V-zone home with the ocean physically there in the backyard. The combination of the high tide and the posted flood and wave height levels had the hoped-for effect on
the listeners.

Alternative locations were in either the less dynamic A-zone homes or the beach association meeting house. These were used when a V-zone home was not available (sometimes because of owner reluctance and other times because the beach association president was adamant about using the hall so more people would benefit). In these instances, the group met at the shorefront and observed the elevations posted on the outside of a volunteer's home, and then moved to the hall for the balance of the presentation.

Contents of the Presentation

The introduction included an explanation of the FEMA flood frequency terminology and related flood elevations. The first phase is to help homeowners understand what this terminology means, and the greatest tool of the entire program is used to accomplish this. It is two pieces of string placed along an outside length of the house at different levels. One level is the projected 100-year flood elevation for that home, and the second, higher level is the wave height elevation. The impact of actually seeing the storm level of the ocean has proved to be very sobering. This display, coupled with two strings inside the meeting place at the same elevations, brings home the damage potential of the 100-year event.

Occasionally we encountered the sentiment that the flood levels displayed were not of much importance locally because of a protective seawall. However, a slide sequence, borrowed heavily from the FEMA New England presentation, demonstrates what happens to a seawall in a severe coastal storm. The town of Scituate, Massachusetts was hit by a winter gale in the spring of 1978, and though it did not reach hurricane proportion, the destruction of the storm was great. The slides show the direct wave attack on the seawall, its resulting collapse, and the destruction of the supposedly safe homes behind it.

It becomes obvious to those in attendance that when a storm of magnitude does strike the Connecticut coast, they will be in danger. If it is a large and destructive storm, there may be nothing anyone can do but evacuate. However, there are plenty of things for homeowners to do before the storms to lessen their losses, and instruction in mitigation methods is the third phase of the seminar.

Each person receives a copy of a hazard mitigation manual and we go through it together, section by section, concentrating heavily on the chapter entitled, "Options and Techniques for Reducing Flood Damages." Permanent,
contingent, and emergency measures are all described and the options—from elevated structures to wet and dry floodproofing to sandbagging—are well illustrated. A close review of each is included. The home in which the meeting is being held is then assessed for its potential losses. Preventive measures and proper cleanup and repair techniques make up the greatest portion of the information in the text.

Information on the NFIP, and a floodproofing cost-benefit analysis follow to make the manual and seminar as comprehensive as possible.

Residents' Current Awareness

It was a surprise to the DEP staff, on one hand, that current awareness of flood hazards and mitigation was as high as it was. One resident had raised the utility wiring in his basement to above the highest water line he had seen, and others had put in new patio porches at, or above, the 100-year flood elevation. Still others knew about littoral drift and erosion. On the other hand, there were groups similar to one gathering of beach association presidents and their elected leader. Of the nine people in attendance, eight were not aware of the existence of the NFIP, and they had a grand time locating their land holdings on the FIRMs.

The greatest percentage of the population was between the two extremes. Most residents had some knowledge about flooding in their area, but some of them felt that they had already seen the greatest wrath of the ocean. Indeed, they had been through seasonal, and sometimes potent, localized storms, but they have ranged from nuisance flooding, to some severe, highly localized damages.

Exposure

The bulk of the publicity for the CHFPP in its pilot year was through word of mouth. However, we were fortunate to get some "press" in a small circulation regional magazine, as well as an article in the DEP's monthly publication. The desired time of publication for these articles was simultaneous with the storm season.

Applicability

The program proves versatile in its applicability to almost any flood-prone area, whether the concern is wave-induced coastal flooding, still-water inundation, or riverine floods. The emphasis can easily be changed from barrier beach housing to larger homes behind a seawall with little format adjustment. The principles of flood prevention are similar wherever there is
the potential for high water.

The smaller scale of Connecticut's coastal flood problem made the program easily workable, but larger coastal states would have to expand their efforts correspondingly. While the results of every such program are extremely valuable, a larger state's problems are magnified by both population size and geographical problems of coordination. This program is definitely workable, but easier to do on a county-wide basis than statewide.

The Future of the Program

The pilot Coastal Homeowners' Flood Preparedness Program of 1984 was a success. Overall cooperation of the municipalities was good. The beach associations had an honest interest in their constituents' safety, the preservation of their community niche, and increasing their own general knowledge. The homeowners that attended the seminars proved their interest by virtue of their voluntary attendance, the questions they asked, and their compliments to the program.

The information the coastal residents receive in the Flood Preparedness Program is the information that can save the federal government money through reduced insurance claims.

With three summers of research behind us, we are firmly convinced that shoreline property owners don't understand the potential catastrophic flood losses that they face, but they will listen to us if we prepare materials they understand, and if we, as public agencies, leave our government office buildings and go out to them at the shorefront.

Because we set up, experimented with, and worked the bugs out of our pilot project at our own expense in 1984, FEMA has funded us to improve and expand the 1985 program. Our immediate goal this year is effectively instructing 1,000 heads of households, representing about 2,100 coastal residents, in a large cross-section of our potentially hazardous shoreline communities.

If we can convince ten residents to purchase flood insurance, or persuade as many households to move expensive rugs and miscellaneous other valuable furnishings above predicted flood levels when they realize flooding is imminent, our program will pay for itself in reduced insurance claims.

Everyone who attended any seminar has been sent, one year later, a questionnaire to establish whether or not any mitigative precautions have been taken. Only when these results come in will the long-term impact of our seminars be known.
The Arizona Floodplain Management Association (AFMA) was founded in 1982 by floodplain administrators responsible for management, enforcement of regulations, and flood hazard mitigation in their respective communities. The Association is the first of its kind in the country and was the first state chapter to be accepted into the Association of State Floodplain Managers. AFMA is a non-profit corporation that provides a means of communicating changing state and federal regulations, and the latest methods available to accumulate and analyze technical data. The necessity of such an organization is evident by the fact that all 89 communities within the state participate actively in the National Flood Insurance Program (NFIP). Specific goals of AFMA include: 1) enhance cooperation among the private sector, local, state, and federal agencies responsible for floodplain management; 2) encourage and promote new and innovative approaches to managing the state's floodplains in order to achieve the greatest social and economic benefit and general welfare for the citizens; 3) provide a forum for the education and training of those involved in floodplain management.

Membership

The Arizona municipalities and communities that have elected to participate in AFMA are afforded one representative with voting privileges. These general voting members serve as elected officers and vote on all Association business. Associate membership in AFMA is open to all citizens and private firms with an interest in floodplain management. These members contribute to the various technical and educational workshops and programs, and provide valuable input to assist the Association in meeting its goals. AFMA has grown
from 18 general voting members and eight associate members in 1982, to 49
general voting members and 99 associate members in 1985.

Organization

The general voting members hold quarterly meetings at various municipali-
ties throughout the state each year to which the associate members are invited.
From the membership, specific committees are formed to concentrate on the
mechanics and goals of the Association.

The training and education of floodplain administrators and associate
members in various technical and non-technical subjects is necessary to enable
the Association to meet its goals and objectives. There are five vehicles
within AFMA to provide training and education: 1) technical and non-technical
seminars held during quarterly meetings; 2) sponsorship of short courses;
3) workshops; 4) quarterly newsletter; 5) participation on ASFPM committees.

Technical and Non-Technical Seminars

Technical Topics

During each quarterly meeting the Association offers technical and non-
technical seminars and lectures by its general membership and guest speakers
recognized for expertise in their specific fields. The topics are related to
floodplain management problems generally associated with the region of the
state where the meeting is being held. Technical topics have included:

Sand and gravel operations. An actual court case involving a sand and
gravel operator versus Pima County regarding enforcement of its floodplain
management ordinance. The case was used to present the various hydraulic and
geomorphic effects the operation had on existing floodplain development struc-
tures (including bridges) and river morphology. The discussion detailed the
impacts on the river system, including headcutting, channel bed degradation and
aggradation.

Case history of bridge failure. Review and analysis by Simons, Li &
Associates of a bridge failure due to flooding and erosion caused by upstream
floodplain encroachment. The presentation outlined specific documentation and
photographs detailing the changes to the natural floodplain due to encroach-
ment.

U.S. Army Corps of Engineers Urban Study Program. Explanation of the
procedures for communities to request assistance for flood control projects.
An ongoing urban study program within the Phoenix metropolitan area was dis-
cussed in detail to demonstrate the extent of the Corps involvement.


Discharge frequency analysis. A presentation by an expert hydrologist on flood frequency analysis for the Santa Cruz River in Pima County, Arizona. Due to the discharge recorded during the flood of October 1983 (largest flood of record), a need to revise the regulatory discharge developed for the Federal Flood Insurance Studies was apparent. Due to urbanization of the lower portion of the basin since 1960, in conjunction with increase of average annual rainfall, frequency of significant floods increased as compared to the record preceding 1960. By utilizing the annual maximum floods for the past 25 years, a log extreme value line indicates a threefold increase over the existing regulatory discharge.

Fundamentals of levee and dam design. Arizona Department of Water Resources officials explained their role in the review of design plans, inspection and construction coordination of dams, reservoirs and miscellaneous flood control projects. Also, discussed were the criteria for obtaining funding assistance from the state for flood control projects.

Real time flash flood warning. Presentation by Maricopa County Flood Control District on the selection of equipment, the installation, and function of precipitation and stream gauges for various watersheds surrounding the Phoenix metropolitan area.

Other technical topics have included the influence of geology on storm water runoff management, impact of urbanization on channel stability, design of protection for existing development on alluvial fans, and soil cement application and use in Pima County for flood control projects.

Non-Technical Topics

State legislative issues. Ongoing reports by attorneys associated with AFMA on proposed state legislative issues involving floodplain management regulations. These presentations guided the Association's successful effort to improve state floodplain management legislation.

Public immunity laws. Municipal Attorney's definition and interpretation of immunity protection for public officials. Specifically, public agencies and employees no longer can rely on good faith immunity as a defense in an immunity case filed against public officials.

Panel discussion. To present various viewpoints, panel discussion have been held involving representatives from the federal and state agencies, public and private engineers, attorneys and university professors. Topics have included the Letter of Map Amendment Process, interpretation of state and
federal regulations, various floodplain management ordinances, assistance to smaller communities, flooding on the Colorado River, and the October, 1983, floods in southern Arizona.

**Multi-use flood control projects.** A presentation on and tour of a unique multi-use urban flood control project given by a former city official. The presentation included a discussion of the planning and construction of the project which successfully incorporated flood control design with open space, parks, golf course and transportation facilities.

**Real world data base.** A presentation by an aerial photogrammetric firm on the processes of aerial photography and topographic mapping as it relates to floodplain delineations. The presentation outlined scheduling of aerial photography as dictated by weather conditions, types of photographic equipment, and the various mapping scales and desired accuracy, and the associated costs.

**Manufactured housing regulation.** Representatives from the State Office of Manufactured Housing outlined state standards and laws regarding the installation of mobile homes in floodplains. It was noted that due to an unenforceable regulation, neither state nor local building inspectors are inspecting for the required support systems and/or wind tie-downs.

**Floodplain management tools for alluvial fans.** A presentation by Anderson Nichols on identifying the flooding characteristics, flood dynamics and flood hazard of alluvial fans. The discussion detailed comprehensive approach to non-structural floodplain management techniques and structural flood control improvements including planning, design and construction of development on alluvial fans. A video tape to aide the discussion of a physical model was shown to demonstrate structural and non-structural approaches to development on a alluvial fan.

Other topics have included a three-part seminar on non-technical hydrology, efforts to promote similar organizations in California, Nevada, Utah and New Mexico, presentation by the U.S. National Park Service and their experiences of flash floods and early warning systems, and channel bank erosion and lateral migration of channels and their impact of floodplain management regulations.

**Short Courses**

AFMA has sponsored two short courses: one with the American Society of Civil Engineers, and the second as a sole sponsor. The course books used for both short courses were made available to AFMA members who could not attend
to insure that all members are familiar with current technology.

**Open channel hydraulics.** The Civil Engineering Department of New Mexico State University discussed the fundamentals of open channel flow and gradually varied flow principles. The intensive, concentrated program also involved the use of computers to analyze hydrologic and hydraulic problems.

**Rainfall-runoff modelling.** Consulting engineers from Denver, Colorado presented the concepts of runoff modelling, rainfall losses, runoff hydraulics, and applications of computer models.

**Workshops**

In addition to the seminars, AFMA also has had several workshops held between the scheduled quarterly meetings to discuss special problems. Topics have included legislative issues and review and participation in FEMA's Map Initiatives Project Study (MIPS).

**Quarterly Newsletter**

The Association publishes a quarterly newsletter to inform members of the activities in flood hazard management, current and proposed changes in the NFIP, and important legislative activities affecting state and local flood hazard management programs. In addition, the minutes from each meeting and items of interest to the Association members are also included.

**ASFPM Committees**

AFMA, as a member of the Mapping and Engineering Standards Committee of ASFPM, played a major role in participating in the Mapping Initiatives Project Study. Of the 300 nationwide responses to FEMA's questionnaires, more than 65 questionnaires were completed by AFMA Members. AFMA members participate actively in various ASFPM committees, and can thereby aid in the dissemination of information to all AFMA members.
EFFECTIVENESS OF PUBLIC INFORMATION PROGRAMS
DURING 1983 COLORADO RIVER FLOODING

Julian F. Rhinehart
Bureau of Reclamation -- Boulder City, Nevada

What once was one of America's wildest rivers is now one of its most important. Although the majority of its drainage has four inches or less of rain annually, the Colorado River is a reliable source of water for over 14 million people and one and a half million acres of some of the world's most productive farmland.

Operated to provide both flood control and much needed water storage, the Colorado now is also one of the world's most regulated rivers. In order to provide flood control while still maintaining consistently high storage levels, the Colorado River must be controlled to the extent that under normal conditions only enough water is released from reservoirs to meet downstream water orders.

Although predicted many years earlier, the conflict between Colorado River storage and flood control needs did not become visibly evident until 1983 when unusual conditions combined in an unprecedented manner.

Late spring snows, unseasonably cool weather followed by a sudden heat wave, and full reservoirs combined to quickly push a slightly above average runoff forecast into a record inflow in less than a month. Subsequent flood control releases during the remainder of 1983 created a challenge to both Bureau of Reclamation engineering and information personnel.

From a public information perspective, five points stand out in the 1983 Colorado River flood control operations:
1. Colorado River Floodway Encroachment
2. Public Information Efforts Prior to High Releases
3. Public Information Program
4. Position of News Media
5. Reaction of News Media
Colorado River Floodway Encroachment

The damage sustained was unusual in that, with one exception, structures damaged were in a floodway which had been identified over 40 years earlier. These were structures which had been constructed inside the floodway, and even sometimes between levees, after the floodway had been defined.

Encroachment in the three-hundred-mile-long floodway between Davis Dam and the Mexican border occurred primarily on land in private ownership. Problem areas occurred in each of the three lower basin states -- Arizona, California, and Nevada.

This reach of the Colorado River bisects a desert, and it is one of the few water resources in the area. Much of the river is just a few hours drive from the metropolitan areas of Las Vegas, Los Angeles, and Phoenix.

The 1960-1980 push for recreational and second home development occurred during a 20-year period of artificially low and stable Colorado River flows caused by the filling of upstream reservoirs. In the absence of routinely occurring flood control releases and in the presence of newly constructed dams, people gained a false sense of security. The flood plain was invaded and developed in some areas. Local officials, often located in a county with a low tax base, were lax in the enforcement of flood plain regulations.

Public Information Efforts Prior to High Releases

For many years, Bureau of Reclamation and local governmental personnel had been discussing the inevitable forthcoming high water situation with the local citizenry. Their reaction was generally polite, but doubting.

As upstream Lake Powell behind Glen Canyon Dam approached its upper levels in 1976, the Bureau of Reclamation published a report forecasting the eventual return to routine flood control releases. The following year, an information program was conducted in six of the riverside communities along the lower reaches of the river.

Although well publicized in the news media and supported with informational
pamphlets, the program drew little public interest. This was mainly because it was being conducted during one of the worst droughts in recent western history.

Two years later, a public information program jointly conducted by the Bureau of Reclamation and the Corps of Engineers met with little more success. Once again the same riverside communities were visited, and while meeting attendance was good, the inevitability of flood control releases was not comprehended. Rather than to accept the realities of flood control being presented, residents offered objections and criticism to the flood control release plan being discussed.

Lake Powell behind Glen Canyon Dam filled in 1980, but this was followed by two dry years. In 1983 the era of artificially low and stable releases in the lower Colorado River valley came to an end. Forecasted runoff had been only slightly above normal until mid-May. By June 1 the predicted runoff was 131% of normal, a figure which would jump to 210% by the end of the month.

Public Information Program

In early June, releases from Parker Dam were increased to 21,000 cubic feet per second (cfs), a damaging release level. Public information personnel and Bureau engineers visited the area and met face to face with potential flood victims and members of the news media. Engineers provided technical information on protective measures as well as estimates to water level elevations with the flood control releases.

The Region's river scheduling office initiated telephone contact with emergency service coordinators in Arizona, California, and Nevada. In the months following, any change in river operations would be preceded by a lengthy series of calls to these offices.

Long before the high water became a concern, the regional office in Boulder City, Nevada, had developed a Public Affairs Plan. It emphasized that the primary mission of the information program during this time would be to get information out for the protection of life and property. This effort would be directed to both the people being affected, and to the news media serving them.
An aggressive information effort would be conducted to get river operation facts out to those most likely to be impacted. The Bureau of Reclamation recognized that while the flood situation was naturally caused, the damaging releases would be man-scheduled. For this reason some public criticism of their river operations was anticipated. No attempt was initially made to defend these actions. Instead of attempting to place blame for the flood damage on the people who encroached upon the floodway, emphasis was placed upon objectively getting the facts out. Bureau statements were not to be defensive or accusatory.

Nearly all media contacts were coordinated through the regional office rather than from the field. This eliminated conflicting reports and answers, while at the same time providing a single contact point for answering questions and quelling rumors.

Public information personnel, particularly those brought in on temporary duty from other offices, were encouraged to be both open and responsive to questions from the public and news media. Both the Regional Director and Regional Public Affairs Officer, who served as primary spokespersons for the Bureau, provided members of the news media with their home telephone numbers.

The Regional Director frequently, and in some case daily by telephone, briefed Congressional staffs from the three lower basin states on forthcoming river operations. This provided another route for relaying information to their constituents.

Toll-free 800 telephone lines were installed to provide a daily update of river operations, levels, and projected changes. These not only were extremely well-received by the public, but they greatly reduced the number of relatively routine telephone calls which information personnel must handle. These people remained available to respond to more detailed inquiries.

**Position of News Media**

Most members of the news media were newcomers to Colorado River operations. Without background on how or why the river is operated to provide both flood control
and water storage, they had difficulty understanding the significance of the floodway. Numbers also posed a problem. Frequently reporters would be overwhelmed with four sets of five digit releases expressed in cubic feet per second. A fact sheet of river operation terms and procedures would have greatly facilitated their comprehension.

Reaction of News Media

Rather than to explain the facts, many news articles sensationalized and focused on the damage which occurred. This negative publicity seriously affected the local economies. Many people normally vacationing on the Colorado River rescheduled their plans even though some of the river, particularly reservoir areas, remained open to recreation use. Losses of tourism and recreation revenues exceeded the physical flood losses sustained along the river in 1983.

After the first wave of sensationalism, coverage of the media was generally fair and objective, even though usually laced with inaccuracies. A wire service reporter, unfamiliar with Hoover Dam operations, was told that in a few days water would begin to flow over the top of the Hoover spillway gates. The next morning newspapers across the country carried accounts of how water would soon be flowing over the top of Hoover Dam.

Most of the flooded areas were located in sparsely populated areas without local daily newspapers or television stations. The most reliable manner of communicating with these publics through the news media was with their local radio stations, many of which did not have wire service connections. Any time these media outlets were called upon for assistance, they eagerly responded with news interviews, actualities, or talk shows.

Summary

Through the channels listed, the Bureau of Reclamation was able to successfully communicate flood information to the victims and the general public. Although they may not have liked what they heard, for the most part they did understand what they heard.
Though much criticism of the Bureau's river operations was encountered at first, the initial non-defensive policy of responding just to river operations eventually paid off. Later in the summer, after emotions had subsided but the high releases had not, third party spokespersons spoke positively on behalf of the Bureau and its procedure for operating the river.

The centralized media response policy lessened conflicting reports and was most effective in addressing rumors, but the remote location may have created a feeling of detachment from the scene and inaccessability.

Two series of Congressional hearings in September and October pointed out that the Bureau had correctly operated the river and that if changes were in order, those changes would have to be brought about in coordination with the seven basin states to whom the river water belongs.

This was substantiated even further the following year when an even larger runoff occurred in a more traditional manner. Because the initial forecasts were high, a sufficient amount of space was created in the reservoir system to handle this inflow with only a minimum of damage.
Introduction

Historically, the agencies charged with implementing the state and federal floodplain management programs have always recognized the need for providing program information to both the general public and the local municipality's chief zoning officials. Little effort, however, has been expended to provide good technical information for use by the local city, village or town boards of appeals or county boards of adjustment, who have the statutory authority to grant variances and overturn decisions of the zoning administrator. It has long been recognized that a community can have an excellent zoning ordinance and a good zoning administration staff which administers the local zoning program correctly only to have their decisions overturned by well intentioned boards who are swayed by the emotional issues rather than the factual evidence they are required to consider.

These situations have long been noted and documented through the Federal Emergency Management Agency (FEMA) initiated Community Assistance Program Evaluations (CAPE) and through the Wisconsin Department of Natural Resources (WDNR) program audits which are now being conducted on a regular basis. Based upon these facts, the WDNR has undertaken an effort to develop and disseminate good technical information for these Boards to use. The ultimate objective of this effort has been to improve the decision making abilities of the local boards of adjustment and boards of appeals, thereby maintaining and securing the integrity of the local floodplain zoning ordinance and the state and federal floodplain management programs.
Board of Adjustment and Board of Appeals Informational Materials

Wisconsin used a $2,500 training grant obtained from FEMA through Wisconsin's Division of Emergency Government (WDEG) to develop the board of adjustment and board of appeals informational materials. The WDNR contracted with a local attorney who was a recognized municipal zoning authority to develop the materials in a manner applicable to county boards of adjustment and city, village and town boards of appeals.

Although boards of adjustment and boards of appeals are similar in nature, the statutory authority and case law differed enough to warrant individual handbooks to be produced along with separate documents establishing rules of procedure for city, village and town boards of appeal and rules and by-laws governing county boards of adjustment. The remaining information which was developed entailed five checklists addressing the following topics: 1) Procedures for applicants: zoning appeals, variances and special exceptions; 2) consideration of staff recommendations; 3) conducting public hearings and on site inspections; 4) preparing and submitting board decisions; and 5) preparing case files and presentations for court hearings. Contained within these checklists are numerous forms and explanations of how to implement the information into a local zoning program.

Distribution of Materials

In Wisconsin, there are 70 counties and more than 485 incorporated cities and villages which have been recognized as having a flooding hazard potential. All of these municipalities (i.e., counties, cities and villages), were sent a complete packet containing the appropriate information for their respective boards.

Included with the distribution of materials was a letter explaining who could be contacted for additional copies of the handbooks. Sufficient copies of the handbooks were produced so that each member of each board of adjustment or board of appeals in Wisconsin could have a personal copy.

The expenses involved in editing, producing and distributing the packets of information and the handbooks were absorbed by the WDNR.
Implementation of Training Programs

In an effort to provide a clear understanding of what statutory authority and responsibility a quasi-judicial board of adjustment or board of appeals possesses, a statewide training program was initiated.

City, Village and Town Boards of Appeals

The WDNR and the University of Wisconsin Extension (UWEX) joined forces in presenting a series of three Educational Telephone Network (ETN) programs presented through a statewide radio telephone system. The UWEX has ETN outlets in central locations within each county in Wisconsin. Because of the relatively large numbers of incorporated municipalities (greater than 550) throughout the state, it was recognized that individual workshops could not be effectively conducted statewide. By utilizing the statewide telephone network system of the UWEX, the entire state was effectively canvased within a reasonable period of time at a minimal expense.

The ETN sessions consisted of presenting and discussing the board of appeals handbook over a period of three 80-minute sessions during which the participants were able to have questions answered through an open discussion format.

County Board of Adjustment

The WDNR conducted board of adjustment informational workshops throughout the state's 70 counties. The local county zoning administrators have an active state organization entitled "Wisconsin County Code Administrators" (WCCA). The organization assisted the WDNR in scheduling and coordinating the date, time and place of the informational workshops.

Staff from the WDNR comprised of an attorney and myself, as the program staff specialist, have conducted 11 workshops in centralized locations throughout the state. More than 60 of the state's 70 county boards of adjustment and their zoning staff and legal advisors (i.e., corporation counsels or district attorneys) have attended the informational workshops.
Follow-up Informational Programs

Based upon the attendance and discussion generated by the ETN sessions and the county board of adjustment workshops, it is apparent that a real need exists for continued informational programs for not only boards of adjustment and their supporting zoning and legal staff, but also for municipal planning and zoning committees who are responsible for adopting and amending zoning maps and ordinances.

At the end of each of the board of adjustment workshops participants were asked to complete an evaluation critique. The critiques that were returned were complimentary for both the information contained in the handbook and the opportunity for the discussion during the workshop. The majority of the comments favored the development of a follow-up workshop discussion format which would address such items as what the Board should and should not do when conducting a hearing, how to determine what is and isn't factual evidence, and how to properly document decisions. All the remarks received favored the workshop discussion format and seemed to evolve around one main theme which was that the materials and workshops should have been provided when the floodplain management program first began.

Reports from municipal zoning administrators indicate that their boards of adjustment and appeals have shown marked improvements not only in the hearing procedures, but also in the manner by which the boards consider the factual evidence associated with the application request, and how decisions are made by applying conclusions of law.
THE EVERGLADES IN SUBURBIA

Alf Siewers
Chicago Sun-Times

I know a town where local officials spent millions of dollars to build a system of dikes. The system was unveiled with great ceremony as the final solution to the town's flooding problems, pending completion of a larger federal project. Spring came, and basements were wet again.

That's typical of the kind of publicity that flood control projects often garner, and that floodplain management is often unfairly confused with. People not in the neighborhood tend to see such efforts as ineffective boondoggles, subsidizing people who shouldn't have built there anyway, or as government intrusion into private property rights.

Journalists, who often don't take time to know better, cover flood issues when they reach a crisis, but often don't offer any consistent coverage of floodplain issues.

What can be done about this situation? I suggest the answer is twofold, and involves substance as well as style. The importance of the topic is obvious. According to the National Weather Service, flooding tends to cause greater average annual losses in lives and property damage than any other natural disaster. At the same time, the whole issue of water management is gaining attention in the media. The Water Resources Council, for example, estimates that "seventeen subregions have or will have a serious problem of inadequate surface-water supply by the year 2000" (Anderson, 1983). Projecting a truthful image of floodplain management as a water issue, not just a technical one, and as an environmental approach, not just a public works one, is essential.

This is the difference between just larger levees, dams and reservoirs, and landscaped water parks that also provide water supplies for the community. It's the difference between headlines about pork-barrel water projects adding to the federal deficit, and ongoing coverage of innovations that involve private entrepreneurs and community groups.

Floodplain management itself provides a departure from the necessary but
perhaps excessive government approaches of the past to flood control. As one study concluded of old-style flood control projects, "Flooding eased upstream, but downstream areas grew increasingly vulnerable as their neighbors upriver sent them their flood problems, C.O.D." (Krohe, 1982).

Treating floodwater more as an economic resource, as a solution to problems of water scarcity and pollution, will link floodplain management more to economic development. There are approaches available for making this relation more clear. In the form of pilot projects, these approaches can garner more attention for floodplain efforts, become a forum for educating the public, and answer local officials who fear floodplain management will reduce tax revenues without tangible benefits.

The use of land treatment methods for dealing with waste and storm water is an important example, a system that has been compared to a spaceship in its self-contained potential. (As an aside, I note that one conservation publication in Illinois has suggested sending wetlands into outer space to manage water resources on space stations.) Such "space age" systems that combine solutions to waste, water and flood problems will capture the imagination of both the public and skeptical journalists, particularly if their cost-effectiveness holds true in the future. This cost-effectiveness is indicated by the involvement of private developers.

In Itasca, Illinois, for example, the Hamilton Lakes project of Trammell Crow Company is using a land treatment system that has significantly reduced runoff problems. "Outside of Hamilton Lakes," says one description, "hardly any other community in the nation can look favorably upon urban stormwater as an added, valuable source of water supply" (Sheaffer and Stevens, 1983). Here, after government water systems proved inadequate, the company built its own system by which landscape lakes take waste and storm water from the hotel complex and filter it back into shallow aquifers through irrigation systems.

Another development, a high-tech park planned for Colorado Springs, Colorado, is designing a similar system to be run by a special government district matching the development's borders. The proposal for the district says: "An innovative on-site wastewater management plan will be incorporated into the development, providing the basis for recreational open spaces and campus-like environs, as well as achieving goals of recycling, conservation and efficiency" (Sheaffer and Roland, 1984).

A final example of the type of pilot program that can generate excitement
among the media because of its larger vision, and among the public because of potential cost-effectiveness, is the artificial wetland. In the Chicago area, a private environmental group has incorporated and obtained corporate and government funds to design such large wetlands on public land along a floodplain. The environmentalists want to restore an example of the wetlands habitat that once covered Chicago. Interested officials want to find out the potential for waste treatment and flood control of such a natural system strengthened by careful human management. Corporate officials are interested in the potential of such systems as low-cost (and more aesthetic) alternatives to mandated treatment plants and drainage systems. Proponents argue it has potential both on a small-scale private level and on a larger scale in public lands along rivers and streams, where it can double as conservation and recreation land.

That's the kind of happy marriage of interests that the free market ideally is supposed to foster. And it's the kind of marriage that floodplain management is all about, and rightly so at a time when people are increasingly concerned about the cost of government expenditures.

Nobel Prize-winning economist Friedrich Hayek puts it this way: "It is most important for a healthy society that we preserve between the commercial and the governmental a third independent sector which often can and ought to provide more effectively much that we now believe must be provided by government. Indeed, such an independent sector could to a great extent, in direct competition with government for public service, mitigate the gravest danger of governmental action, namely the creation of a monopoly with all the powers and inefficiency of a monopoly. It just is not true that, as J. K. Galbraith tells us, 'there is no alternative to public management.' There often is, and at least in the U.S.A. people owe to it much more than they are aware of. To develop this independent sector and its capacities is in many fields the only way to ward off the danger of complete domination of social life by government" (Hayek, 1979).

Of course, there will be a large continuing role for government in flood control. But floodplain management lends itself naturally to this so-called independent sector. And this kind of private and community involvement not only ensures that those most interested in floodplain management will be involved and accountable, it also ensures good publicity and public support for floodplain management efforts.

How does this work in practice? Let's take a few examples of the indepen-
dent sector in action. It can start with something as small as a Boy Scout troop adopting a wetlands area as an ongoing conservation project, or adoption of a floodplain area by a local Audubon Society. In Chicago, an Audubon chapter actually owns a few acres of land in a marsh that it is working to turn into a larger park, using flood control as an argument. In Elgin, Illinois, a private game preserve owns a large tract of land along a river where it is restoring a wetlands area that will benefit flood control.

The potential for large-scale and consistent involvement of the independent sector in floodplain management is indicated in the efforts of Ducks Unlimited, a group that has collected money from thousands of individual hunters to create wetlands preserves covering millions of acres in Canada. Now this same group is providing matching funds to state governments for wetlands efforts.

Creating tax incentives for open lands along floodplains and preservation and creation of wetlands is an important policy tool for future private-sector involvement in floodplain management. Further development of legal tools is important as well. Ducks Unlimited often purchases conservation easements and creates land trusts; such mechanisms, as well as deed restrictions and covenants, could be a creative, popular, and economical supplement or, in some cases, alternative to centralized floodplain planning. And obviously insurance companies have an important role to play in this process as well.

The potential for such involvement for both flood control and environmental preservation has been indicated in studies done by the Political Economy Research Center at Montana State University (Baden and Blood, 1984). Resource economist Terry Anderson has raised the possibility of revising water law to establish clearer property rights to water and greater accountability for water runoff, thus increasing incentives for floodplain management.

Administratively, devices such as user fees and consolidation of parks and flood districts need to be examined. New EPA mandates on storm runoff may be a vehicle for change. These efforts will create interest in floodplain management, greater awareness of floodplain efforts, and build support for projects.

People need to be told what they can do as individuals. Besides holding subsidized insurance or keeping a portable radio handy in case of flood, neighborhood groups should be given information on how creation of small fenlike areas of yards and parks can make for better management of storm runoff and floods. Home owners can be told how grading of land and planting of shrubs can
prevent runoff pollution. Tax incentives could even be offered for such very local efforts, which will also increase media focus on floodplain needs as a consumer issue.

Finally, I'm reminded of a friend of mine who is a Potawatomie Indian. He once took me on a tour in his pickup truck through Chicago's south suburbs, pointing out where ancient trails and villages of his people were. Here were the swamps, here were the highlands where the trails ran, he'd point out. He told of how the marshes once rivalled the Everglades in size, extending far into Indiana, providing Indians with bountiful hunting and fishing as well as sanctuary from enemy raiders.

I think his favorite point on the tour came as we passed a spanking new office development. "They built that on a capped spring," he said, shaking his head. "They don't know you can't really cap a spring."

Then he let out a whoop and pointed. Along the side of the building was a small lake where the parking lot was supposed to be. "Now they're so worried about water supplies," he said. "Well, the water was all here."

It still is. And whether you're a Potawatomie or not, that vision of the interrelatedness of floodplain and water issues will go a long way toward improving media coverage of floodplain management.

References
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AT-RISK RESIDENTS' KNOWLEDGE AND BELIEFS ABOUT STRUCTURAL AND NONSTRUCTURAL FLOOD MITIGATION ACTIONS

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Introduction

Recently a newspaper editorial appeared in the local newspaper of a Louisiana community which is in the process of determining how best to protect itself from a repeat of three devastating floods which have occurred in the last six years. The editorial was in response to the final public meeting held by the U.S. Army Corps of Engineers on a proposed levee system. The community has been informed that the cost to the community (with the proposed new cost-sharing ratio of 65/35 will be 7 million dollars). The community has several concerns: whether the federal government will actually fund the project, how they will fund the community's portion of the cost and why the levee will not protect all affected neighborhoods.

Some six years after the first major flood and two years after the initiation of the Corps's study to suggest flood mitigation action the editorial states:

"In view of this (the problems cited above), local officials and the public might do well to explore other flood control protection measures (italics mine) that wouldn't require federal dollars."

(Slidell Daily Times, April 19, 1985)

It is the contention of this author that to have such a statement made by a seriously and repeatedly flooded community some six years into the process of determining flood mitigation action is an indicator of a planning and decision-making process much in need of revision both in terms of the steps taken and second in terms of the options provided.

While the actual implementation of the flood mitigation actions has been generally in the hands of government officials, the decision-making process as to which mitigation actions are to be taken is a shared one between residents and officials. It is evident from the violations of FIA flood elevation requirements that when the
government decision to implement a mitigation action is not supported by the local community, limited effectiveness will be realized (Houck, 1984). It is also evident that as the local community is forced to pay a larger portion of the bill, the community will become even more the locus of the decision-making. And, in addition, to the extent that individual homeowners come to determine that individual household mitigation actions may be cheaper and more controllable than public ones, the locus of decision-making will become even more "local," in this case household based.

If these proposed assumptions about the locus of decision making are correct, it follows that affected residents of flooded communities should be seen as key "actors" in the efforts to reduce the impact of flooding and the cost of damage. However, as the above editorial implies, the level of knowledge about possible flood mitigation actions may be very limited and may be quite uneven among types of action and types of residents. It is the goal of this research to examine empirically the level of knowledge and beliefs which are held by at-risk residents about both structural and nonstructural flood mitigation actions.

Methods

The community of Slidell, Louisiana is a small-town turned suburb of New Orleans some 30 miles northeast of the city. It is located in St. Tammany Parish, one of the 12 fastest-growing counties in the United States. The topography of the community is flat and laced with rivers and bayous. It is located both within the floodplain of the Pearl River and the coastal zone adjacent to Lake Pontchartrain, a brackish body of water some 30 by 50 miles wide connected by passes to the Gulf of Mexico. The residents of the community have migrated there either from the inner-city areas of New Orleans or from out-of-state as a result of federal government aerospace industry and other federal government facilities. The income of the community does vary although the middle and upper middle classes predominate. The community experiences three types of flooding: flash, river and lake (ocean) and has been seriously flooded three times since 1979, the last time in 1983 when over 750 houses were flooded and some 3500 people were affected.

The data reported herein were collected by the administering of a 10-page, 135-item questionnaire to residents living on streets which had been flooded in the 1983 flood to the extent that at least one house had been flooded. Some 31 neighborhoods
--distributed among the three types of flooding--were identified as the most seriously flooded and residents in them surveyed. The response rate was 43 percent which yielded 897 questionnaires.

Findings

Residents were asked to review a list of flood mitigation actions. Included in the list were both structural and non-structural actions which could be taken either prior to residential development to prevent flooding or after development to reduce future flooding and damage. The actions were obtained from numerous studies of flooding and were restricted to those which appeared to have relevance to the flooding in Slidell. Respondents were asked to indicate (1) if they were familiar with the terms, (2) if they believed in general they are useful and (3) if they believed the actions would be useful in their neighborhood or home.

Out of the 23 mitigation actions mentioned the average number of actions with which respondents were familiar was 16.4 (71 percent) (see Table 1). The structural actions were the most well known (84 percent) while the non-structural the least (65 percent). House floodproofing actions were in the middle (74 percent). Resident knowledge of specific actions also shows that structural changes are much more commonly recognized than is floodproofing and especially the nonstructural actions. The least well known of the structural--diverting the flow with dams--was familiar to 75 percent of the respondents.

The nonstructural actions were sharply dichotomized between those with which the respondents had familiarity and those which they did not. Four nonstructural actions--acquiring flood insurance, restricting neighborhood density, having flood gauges in place to provide early warning and the purchase of homes by the government ranked high in recognition. However, considerably less well known were those actions which would result in the government controlling floodplain development: restricting of the types of use of the floodplain, the transferring of development rights and the actual acquisition of the floodplain by the government. Also included in the group with which the residents had little familiarity was the enforcement of the 100 flood elevation. That only a small percentage (40 percent) indicated knowledge of this action is very surprising. Two possibilities exist. First the phrasing of the question may have been confusing. It was phrased, are you
TABLE I

ACTION USEfUL
IN GENERAL

4.6

TOTAL

3.3

1.2

2.3

3.5

2.0*

4.2*

6.2*

2.3*

4.4*

6.6*

2.0*

4.0*

6.0*

ACTION USEFUL IN NEI6HBORHOOIl

kHOI/LEDGE AND BELIEfS ABOUT FLOOD MITIGATION ACTIONS (STROCTURAL AHD NONSTROCTURAL) BY AN AT-RISK POPULATION

FAMILIAR
WITH ACTION
9.1

.9

2.5

TYPES Of ACTION

12.S

1.4

3.2

te Score
(. . an' actions out of 17)

C~posi

3.3

72*
69
44
67*
36
4S*
IS
30*
21

5.S

SO*
63
33
71*
43*
66*
12
43*
25*

5.2

75"
54
29
71*
4S"
66*
18
43*
25*

7.6

35
55
51 *
36
15
14
9
8
6

_J88

3417
18
12
16*

.9-

54
7b"
47
43
10
10
12
2
4

4222*
15
11
11
142

1.0-

37
25
10
I
8
S
9

3417
17
9
9
300

.8

72*
24
27*
IS20
13
20
9

12
2223
8
9
133

.6

74*
21
38*
24*
21
14
24
9
.3

70"
20
36*
17*
23*
12
25*
7

5
I
J1
6
7
n=250

6

49
J7
IS
4
12
S
12
2

Structural Coaoposite Score (out of 9)

60

19
12
17
8
8

62

40
54
2S
35
13
21
13

77

S6
85
79

90

85
SI
7J
80
62
64
44
51
45

54
20
22
9
15
9
16
6

92
92
92

75

7S
54
54
26
44
26
35
16
3.6

46
26
37
29
27

1.6

93
82
SI
81
55
55
40
36

77

85
75
67
65

.6

lion Structural toaposite Score
(out of S)
Structural Actions (percent)
Rellove obstructions
Improve storm dra ins
Build p. .ping stations
Adjust roiidbeds
Build general levee system
Dredge ... ter...ys
Build holding ponds
Build ring levees and walls
Divert flow with dcs
Nonstructura 1 Act ions
Acquire fl ood insurance
llestrict neigh. density
Flood warning: flood gauges
Govt purchase of hones
Restr itt type of use
Govt acquire floodpla in
Enforce flood elevation
Transfer developoent rights
Floodproofing Coaoposi te Score
(Out of 5)

<.001

Floodollaoofing HOllIe
F1
walls or .ini levees
Pier construction or lDOdif.
Fi 11 construe tion
ljainscoated sealed walls
"Wrapping" house
MinillUlll ,.,.498
·sign1f1cant

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familiar with: "enforcing the 100-year flood elevation"? If the low rate cannot be attributed to the phrasing, the finding is particularly significant given the fact that the elevating of structures to above predicted flood levels is at the core of the FEMA program and ignorance on the part of the homeowner that such a requirement exists puts all of the responsibility of compliance on the developer and the permitting agency.

Turning to the floodproofing actions it evident that a good deal is known about such activities. Even the "wrapping" of homes—a relatively recently-proposed, and not well developed technique was known by 65 percent of the respondents. That "pier and fill construction" (phrased this way) were less well-known than flood walls or levees may be an artifact of the phrasing. If it is not, again the implications of only 77 and 75 percent recognition are considerable given that these actions are so commonly used to elevate homes above the flood level.

Examining the residents' perceptions of the utility of the mitigation action in general, it is evident that the opinions vary considerably more than the knowledge level. The belief that providing for a more rapid drainage of the water from flooded areas is the direction mitigation action should go is strongly held. Much less confidence is expressed in levees, flood walls, and adjustments to major waterways such as dredging and dams. These opinions are interesting in light of the Corps levee proposal. Local support for raising the community's cost sharing contribution may not be forthcoming.

Nonstructural actions take a dramatic decline from recognition to utility. Only flood insurance is seen by more than half of the respondents as being useful in general and only one restriction on development of the floodplain—limiting neighborhood density—was considered useful by even half of the respondents. Floodproofing actions likewise fell considerably in support from the level of recognition. Only flood walls or mini levees were perceived by about half of the respondents as having general utility.

Turning to the question of specific utility of the mitigation actions for the neighborhood and home of these at-risk residents, it is possible first to see that there is limited support for the appropriateness of the mitigation actions for the respondents. The average number of structural/non structural actions which respondents support is 4.6. And for floodproofing, only .6. Noteworthy also is the considerable range of opinion.
In order to consider the perceived utility of specific mitigation actions for these residents it is useful to separate the residents according to the types of flooding which they experience as well as the severity of their flooding and their perceptions of future risk. It is evident from the breakdown of the composite scores that those individuals who are flooded by river floods, those most seriously flooded and those who perceive that they will be most likely to flood in the future are supportive of the greater number of mitigation actions. Specifically, those resident who experience river flooding are significantly more likely to be supportive of all structural actions except for storm drains and pumping stations, the latter both more useful in flash floods. As severity is very strongly associated with type of flooding (river flooding) and perceived risk likewise somewhat strongly associated, the same structural actions emerge as significant for these two subgroups.

Turning to the nonstructural actions, the first striking finding is the low support for any of the actions. Flood insurance is seen only by half of the respondents as useful to their neighborhoods. Managing the density is only approved of by 20 percent of the residents while those actions which would give government considerable control over the floodplain are almost universally rejected. Looking at the differences between types of flooding, the river-flooded emerge as more supportive. However, those most severely flooded and who anticipate future serious flooding are only more supportive (at a statistically significant level) of flood insurance, flood gauges and government purchase of homes.

Finally, support for the floodproofing of homes is almost unanimously rejected by the total sample. Several actions emerge as more popular with residents experiencing different types of flooding: flood walls for river flooding and pier construction for the lake flooding. Those most severely flooded are in favor of flood walls (the highest support given with 42 percent) and pier construction. And those who perceive future risk are twice as likely to support the "wrapping" concept.

Conclusions

In summary the findings indicate considerable knowledge about structural mitigation solutions with considerably less awareness of the nonstructural and floodproofing actions. The findings also indicate limited support for the utility of the
actions in general and specifically in the respondents' neighborhood or home, especially the nonstructural and floodproofing. As it has become increasingly evident that floodplain development has not been curbed sufficiently by regulation nor structures adequately protected by the hoped-for elevation of structures above flood stage, it has become popular to emphasize nonstructural and floodproofing actions as viable alternatives. The findings of this study however indicate only limited support for such actions by flooded residents even when the actions are proposed for floodplain residents in general and the respondent does not have to come to grips with whether they themselves would wish to "endure" the solution. Such a limited acceptance of the nonstructural suggests considerable difficulty in developing a community consensus for their use. The response to the question of the utility of such mitigation actions for residents' own neighborhoods and homes reinforces the pessimistic outlook. Once a person owns a home in a floodplain, they are unwilling to accept or perceive as ineffective most possible mitigation solutions, especially nonstructural and floodproofing.

It appears evident from these findings that more emphasis must be placed on developing nonstructural actions (U.S. Army Corps of Engineers, 1983) and that educational programs must be developed to inform at-risk homeowners and communities of mitigation possibilities (Motz, 1983). But it is also evident that care must be taken to (1) be sure that those actions proposed are viable, useful solutions and (2) that the reluctance and uncertainty with which residents appear to approach mitigation are taken into consideration. Homeowners appear to have a perceived personal benefit/cost ratio which causes them to reject mitigation solutions, especially nonstructural and floodproofing. This ratio must be understood by floodplain managers and greatly modified—both the perception and the reality (Illinois Department of Transportation, 1984)—in order for mitigation to actually be the fruitful program which it appears floodplain managers are counting on.

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COMMUNITY RESPONSE TO RECURRING AND NONRECURRING FLOODS

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Abstract

Analysis of community response to recurring and nonrecurring floods has significant implications for flood preparedness programs. Comprehensive flood preparedness takes advantage of the most adaptive characteristics of public response to floods. In dealing with the community subjected to a flood, perhaps for the first time in recent history, lessons from recurring flood communities can be utilized in enhancing adaptive response. Conversely, the adaptive aspects of response to nonrecurring floods can be used to increase adaptive behavior in areas where floods recur with some regularity. This paper examines the nature of this cross-over effect and its implications for community preparedness programs.

Introduction

Flooding may well be one of the least problematic hazards confronting human society. While it effects a large proportion of the population, frequent experience with floods and its relatively predictable nature, reduces the band of uncertainty associated with community exposure to floods. Rossi et al. (1983) describe the victimization rates for various hazards. Flood victimization by region of the country ranges from a high of 31.7 in the Middle Atlantic States, to 10.7 victimizations per 1,000 households in the Pacific States. Like emergency preparedness officials, people use their database of (emergency) experience in responding to the impending hazard. Rogers (1984) concludes that the experience of living near nuclear power plants has a direct impact on our attitudes about their operation, safety and acceptability. A minimal linkage between prior experience with various hazards, and perception and recognition of other hazards has been suggested (c.f. Rogers, In Press). This paper addresses the general issue concerning the use of experience with a single hazard in making an adaptive community response. To what extent can emergency preparedness take advantage of the

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experiences of communities with different flooding histories. The more specific question examines community response to floods, how the experience gained in communities stricken with recurring floods may be used in responding to floods in nonrecurring communities, and how experience with relatively rare floods can inform emergency preparedness plans in communities of recurring floods.

Experience and Recognition of Hazard

Public recognition of hazard reduces the uncertainty associated with hazards by delineating the relatively risky and potentially risky from the less risky. Public recognition of hazard seems to rest on a foundation of experience and social values (Rogers, In Press). Historically people have relied on actual experience with hazard as the primary mechanism for recognizing potentially hazardous situations. Many hazards have limitations on actual experience, either because of the limited duration of the experience, or because of the delayed or hidden aspect of the consequences of particular (usually technology based) risks. Because ordinary knowledge is comprised of experience, and the perception of hazard rests firmly on this data-bank of knowledge, prior experience, hazard perception, and emergency response are inherently related. While it might be argued that prior emergency experience has historical meaning beyond the particular hazard, by reflecting a self-efficacy associated with dealing with crisis, reported experience and estimated likelihoods seem to be most strongly related among similar hazards (Rogers 1983 and In press). Furthermore, the strongest relationships among experiences and estimated likelihood of risk result under conditions of exposure to single hazards, particularly flooding and hurricanes, in that order. Hence, the examination of community response to recurring and nonrecurring floods addresses the implications of prior experience for emergency preparedness under favorable conditions. This paper considers the extent to which prior aggregate flooding experience in a community may be used to enhance emergency preparedness for flooding under other circumstances.

Adaptive Response to Flooding

Typically adaptive response to flooding is considered as either structural or nonstructural. Another way of classifying adaptive responses to flooding describes the nature of the response in terms of required level of investment, effort, and coordination. Structural mechanisms are usually employed at the community, or regional level. Technological in nature, they often require considerable investment in achieving effectiveness. Primary examples include the achievements of the Tennessee Valley Authority and the extensive technological accomplishments in the New Orleans area. Technological responses to flood also include weather monitoring
ASPECTS OF REDUCTION

technologies (e.g. satellite and ground station weather monitoring). These technological systems are typically designed to enhance warning time, and monitor flood progression in an area (Curtis 1985).

Organizational responses are usually directed at regional, community or neighborhood level adaptation to flooding. While some communities and neighborhoods take advantage of technological mechanisms, organizational responses are predominantly used by local governments. Organizational responses such as zoning laws and flood insurance programs are well known (Lally 1985), but other efforts at large-scale sandbagging and sheltering (e.g. Salt Lake City, UT) also reflect organizational effort. More indirect organizational responses include the monitoring of weather, snowpack and river systems, warning and information systems. While many of these systems are technological in nature, reasonably effective organizational systems can either stand alone or work in conjunction with available technology.

Individual or household response to flooding is comprised of adaptive mechanisms employed by individuals or small groups, often families. Because people tend to respond to impending crisis in family groups, the individual/household responses to floods play a central role in overall flood mitigation (Rogers and Nehnevajsa 1984, Mileti, Drabek and Haas 1975, Perry Lindell and Greene 1981, Flynn and Chalmers 1980, Drabek 1984 and Drabek and Stephenson 1971). Hence, it is extremely important that flood plain managers understand the dynamics of public response to flooding so that they are able to develop effective emergency plans. Individual/household level adaptive action usually consists of relatively simple actions taken in response to impending danger. Laska (1985) examines public awareness and perceived usefulness of a broad range of flood mitigation actions, while implications of residential choice, as one individual/household mechanism for flood mitigation, is discussed in terms of purchase behavior (Cross 1985).

Public Response and the Cross-Over Effect

Public response to recurring flooding is characterized by an experiential based understanding of the subjective meaning of the impending event. Prior flood experience under relatively unchanged local conditions creates a contextual meaning for flood warnings (e.g. flood stages interpreted in terms of the meaning established by prior reported or anticipated water levels). The prior flooding experience in a given community or region also establishes the nature of adaptive responses in terms of the timing of potential onslaught and utility of specific actions. People exposed to recurring floods are likely to be operationally better equipped to deal with the implementation of emergency procedures. For example, they
are likely to know how to fill sand bags, what things to move, where, how and when to turn off utility service, and in general, the effectiveness of alternative actions. In essence, they have had the opportunity to learn from their past experience with the hazard. Conversely, to the extent that prior experience is inadequate, in the sense of being significantly different from the impending hazard, potentially adaptive response is degraded. This arises when: a) inappropriate responses succeed in prior experience, or b) the impending event is potentially devastating beyond expectations fostered by prior events, or c) prior experience is with particularly devastating events. Success of prior inappropriate activities and impending rare events tend to render inadequate response to hazard, while prior experience with particularly devastating events can lead to over response and misuse of scarce resources. The critical point is to help people, emergency officials and public alike, distinguish between the relatively "rare" and "routine" emergencies.

Public response to nonrecurring floods is characterized by a marked need for information concerning adaptive activity. Without prior experience people are left to adapt rather spontaneously to the changing environment. Hence, the public must be alerted as to the potential for hazard, and notified concerning appropriate actions to be taken in response to the impending hazard. The absence of hazard experience provides the emergency manager with some advantages. For example, it is somewhat easier to contrast crisis with the relatively normal, than it is to distinguish varying degrees of hazard. The lack of hazard experience can leave people to improvise appropriate emergency action, but the emergency manager can emerge as the authoritative leader by directing the response to effective ends. People without experience may indeed turn to the emergency official for guidance in the emergency period. People in nonrecurring flood communities are likely to need greater specification of activity than their experienced counter-parts --- including the appropriate timing of adaptive response. People are likely to find suggestions regarding appropriate actions useful (e.g. locating and unifying family, areas of potential flooding, where to go, what to take, where to meet with family, actions to take prior to evacuation). In essence, a need to teach people concerning their response to the impending flood is likely, but emergency officials must exercise care not to patronize their constituents.

The cross-over effect from recurring to nonrecurring flood situations takes advantage of enhanced knowledge associated with prior experience. The experience of communities subjected to repeated flooding provides information concerning the effectiveness of individual/household acts of protection and avoidance. Such experience provides direct opportunity for evaluation of existing programs (e.g. zoning, flood insurance, and existing emergency plans and preparedness). In short, repeated flood experience provides information concerning the programs that work,
and may suggest modifications needed for communities with different flood problems. People in communities with recurring flood situations have an existing knowledge base which helps them distinguish the utility (vs. futility) of specific behaviors. This is in marked contrast to the need for information (i.e. locus and timing of impact, and adaptive behavior) in nonrecurring flood communities. Establishing the experiential context for flooding situations serves not only to get people's attention, but determine their information needs. Providing too much information can be patronizing, while providing too little may leave people unable to respond effectively. People respond to emergencies on the basis of how the warnings stimulate them to behave (Rogers and Nehnevajsa 1984 and White and Haas 1975), but that behavior is directly influenced by the prior experience context. Hence, it is fundamentally important to understand that context and compare and contrast the anticipated event with prior flooding experience in the community. The experience of other communities besieged by floods is important in repeatedly flooded communities when the impending flood is a "rare" or particularly devastating event. By establishing the experiential context, and comparing the impending event to prior experiences emergency officials are most likely to elicit an adaptive response from potentially impacted people.

Conclusions and Implications

In communities where the knowledge base is rather extensive, like it often is in communities with a recurring flood problem and a relatively stable population, emergency officials are primarily responsible for making existing programs available to the public, accurately comparing impending events with prior experience and assisting the public response. Hence, people in recurring flood communities share the responsibility for knowing about appropriate behavior and available institutional support systems in the community. Emergency managers may effectively rely on institutional support when these support systems are relatively well developed --- as they often are in communities besieged by repeated floods. While emergency preparedness drills are very important for effective emergency preparedness, they may be less important for communities impacted by recurring floods because of the experience of repeatedly responding to actual hazards. In nonrecurring flood communities, flood drills comprise a significant part of the contextual experience, and are thus extremely important in obtaining adaptive public response.

Emergency management based on a comprehensive understanding of underlying social processes places emphasis on programs that work effectively with a minimum of authoritative control. Emergency management officials can systematically take advantage of likely adaptive responses while avoiding associated pitfalls, by
understanding the existing knowledge base created by prior experience. Emergency managers may minimize costs by identifying clear need for specific programs, using standards and regulations to fill significant gaps in "natural emergency" preparedness. Regulations and standards set without such identified need are likely to be ineffective at best. Regulations, standards and social process associated with emergency management are local abominations of global and more abstract measures of flood plain management. A national policy of flood plain management cannot be used without careful consideration of local circumstances any more than water resource policy can be established nationally. People, like watersheds, have different character, they bring different resources and understanding to emergency situations. When flood plain management accounts for these differences it is most likely to be effective. Establishing the existing knowledge base and effectively relating the pending event to events of the recent past are fundamentally important in maximizing adaptive public response in emergency situations, while minimizing cost.

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EMERGENCY RESPONSE AND LAND USE MANAGEMENT PLANNING: THE HURRICANE ALICIA DISASTER

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A. Kim Ludeke
Texas A&M University

Introduction

Hurricanes are a serious national problem. Average annual losses from hurricanes have been projected to reach $5 billion (1978 dollars) by the year 2000 (Wiggins 1979). Some officials alarmed at intensive coastal population growth pressures and increasing time required to evacuate residents from high risk areas have described hurricane scenarios that could claim the lives of more than 10,000 people in large metropolitan areas (Simpson and Riehl 1981).

Traditionally communities have responded to the risks posed by hurricanes by adopting emergency response and land use management planning programs. Emergency response planning programs are concerned with identifying problems that might arise during a disaster and subsequent design of plans of action aimed at coordinating the immediate response and recovery activities of public and private groups and individuals. Land use management planning programs, on the other hand, deal with long-term risk mitigation issues by attempting to influence the location, density and design of public and private development in hazardous areas.

In this paper, we examine the effectiveness of local emergency response and land use management planning programs during the Hurricane Alicia disaster in August 1983. The primary purpose of this examination is to identify the factors that help explain program effectiveness. The authors also draw some preliminary conclusions about the success of local response.

Data on local response to Alicia were collected through a mail-out questionnaire to 51 jurisdictions within the impact area during the fall of 1984. In those communities with both an emergency management coordinator and a city planner a questionnaire was sent to each official in order to obtain as accurate information as possible for both types of programs. A total of 64 questionnaires were mailed. Fifty-one were returned for an 80% response rate. To provide background material for
questionnaire development, we reviewed mail questionnaires (Brower et al. 1983 and Kartez 1984) and interview schedules (Rubin 1983) used in other natural hazard studies.

**Effectiveness of Emergency Response and Land Use Management Planning Programs**

Communities use a wide range of emergency response and land use management measures to reduce hurricane risks. The survey-questionnaire contained a list of emergency response and land use management measures. Respondents were asked to indicate which measures were used by their jurisdictions. Respondents were then asked to rate each measure using scales where the scores would range from "do not reduce risk" (1) to "greatly reduce risk" (5). A mean score for each measure was derived by summing the scores of each measure divided by the number of respondents.

**Emergency Response**

Four types of activities dominate local government responses to a disaster such as a hurricane: (1) finding information for emergency response decision making; (2) organizing public and private organizations and individuals to maximize use of limited time and resources; (3) communicating with citizens to get them to comply with local emergency management plans; and (4) finding equipment from public and private sources in the community and from external sources. Table 1 illustrates the percentage of communities using each of these emergency response measures and the perceived effectiveness of each measure.

A critical initial step during a crisis is the acquisition of information to aid in activating appropriate contingency procedures. The principal information base communities can use during a hurricane crisis is a public-domain hurricane hazard model known as SLOSH (Sea, Lake and Overland Surge Height) which estimates surge heights and wind speeds at 10 minute intervals for a range of hurricane disaster scenarios. This dynamic surge height and wind speed data can be used by local governments to compute when evacuation routes are cut-off relative to time of hurricane landfall. Sixty-two percent of the respondents said their communities employed a procedure to compute estimated cut-off times based on SLOSH data. Surprisingly, however, this procedure was rated least effective (mean 2.52) of all emergency response measures used. Since the SLOSH model data and procedures for computation of local evacuation route cut-off times was first introduced in 1983 -
the same year Alicia made landfall - it is plausible that communities did not have
time to become familiar with SLUSH and the related computation procedures.

Table 1. Emergency Response Measures Used by Communities
and Their Effectiveness1

<table>
<thead>
<tr>
<th>Measures</th>
<th>Frequency/Percentage</th>
<th>Mean for Effectiveness Scales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information access</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procedure to compute SLOSH estimated</td>
<td>(24) 62</td>
<td>2.52</td>
</tr>
<tr>
<td>Organization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procedure to identify actions taken by</td>
<td>(27) 77</td>
<td>3.00</td>
</tr>
<tr>
<td>other governmental authorities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procedure for contacting power and</td>
<td>(24) 60</td>
<td>3.16</td>
</tr>
<tr>
<td>telephone companies for repair schedules</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public address system</td>
<td>(28) 70</td>
<td>3.52</td>
</tr>
<tr>
<td>Television</td>
<td>(18) 51</td>
<td>3.61</td>
</tr>
<tr>
<td>Radio</td>
<td>(29) 74</td>
<td>3.70</td>
</tr>
<tr>
<td>Citizens band radio</td>
<td>(16) 44</td>
<td>3.90</td>
</tr>
<tr>
<td>PIES two-way radio</td>
<td>(6) 18</td>
<td>3.60</td>
</tr>
<tr>
<td>Telephoning residents</td>
<td>(12) 35</td>
<td>3.50</td>
</tr>
<tr>
<td>Organized citizen contact</td>
<td>(22) 65</td>
<td>3.14</td>
</tr>
<tr>
<td>Finding equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private contractors</td>
<td>(27) 73</td>
<td>2.74</td>
</tr>
<tr>
<td>Other local jurisdictions</td>
<td>(28) 78</td>
<td>2.75</td>
</tr>
<tr>
<td>Retail and rental dealerships</td>
<td>(23) 70</td>
<td>2.72</td>
</tr>
<tr>
<td>State Agencies</td>
<td>(28) 72</td>
<td>2.91</td>
</tr>
<tr>
<td>National Guard</td>
<td>(19) 45</td>
<td>2.75</td>
</tr>
</tbody>
</table>

1 When an emergency manager and a city planner responded from the same community only the response of the former was used.

A majority of communities used procedures in their emergency management plans to
coordinate with public and private organizations and individuals. Procedures for
coordinating with public authorities were used more frequently (77%) compared to the
private sector (60%). However, coordination efforts with the private sector were
perceived to be more effective (mean 3.16) than with public authorities (mean 3.00).

In general, communication measures were perceived to be the most effective
emergency response measures that were incorporated into emergency response plans.
Similar to the findings of Kartez (1984), our survey results indicated that
communication strategies established by the community itself were perceived to be
highly effective. Local radio stations, for example, were rated as the most
effective (mean 3.70) of not only all communication measures, but of all emergency
response measures. Locally tailored communication strategies such as public address
systems on vehicles to warn endangered citizens, locally operated two-way emergency
radio systems, known as PIES (Public Information Emergency System), telephoning
residents form local emergency operation centers and organized neighborhood groups to
give door to door instructions to residents were all rated above the mean (3.00) on the effectiveness scale. Regional television news networks were rated relatively high (mean 3.61), while one-way citizens band radio was rated as average in effectiveness (mean 3.00). A majority of respondents indicated that their community used public address systems, television, radio and organized citizen contact procedures, while citizens band radio, PIES and telephoning residents were less frequently used.

Finding equipment from local and external sources was the predominant activity of local governments during the immediate response and recovery period. With the exception of the National Guard, 70% or more of all respondents indicated that their community used private contractors, other local jurisdictions, retail and rental dealerships and state agencies as a source of emergency equipment. However, procedures incorporated into local emergency management plans for finding equipment were generally given low effectiveness scores (mean of 2.91 or less). Notably, state agencies ranked the highest of all sources (mean 2.91).

Land Use Management

The second principal local activity for reducing hurricane risks is land use management for long term mitigation. Table 2 illustrates the percentage of communities using various land use management measures and the perceived effectiveness of each measure in reducing the risk of recent coastal storms.

Police power regulations were the most widely used and most effective land use management measures used by communities to mitigate storm risks. Of all land use management measures (including police power regulations) flood elevation requirement to ensure that flooding in buildings is minimized are used most frequently (91%) and are the most effective at reducing risks (mean 4.43). Storm resistant building standards were used by a majority of communities (58%) and were given the second highest effectiveness score of all land use management measures (mean 4.17). The high frequency of use and high effectiveness scores for building elevation and storm resistant standards is due, in part, to their mandated use for local participation in the National Flood Insurance Program. Also, building improvement regulations take less effort for communities to adopt and implement than regulations that involve controlling land use such as zoning and subdivision regulations. A majority of communities (83%) used subdivision regulations, however, these regulations received
the lowest effectiveness score of all police power regulations (mean 3.70). Although a relatively low percentage of communities used special hazard area ordinances (27%) such as critical area designation of high risk areas and shoreline setback and dune protection ordinances, their effectiveness score was quite high (mean 4.10). This infrequent usage is attributable to the inclusion of both shoreline communities that would use these ordinances and inland areas that would be less likely to use such ordinances.

Table 2. Land Use Management Measures Used by Communities and Their Effectiveness

<table>
<thead>
<tr>
<th>Measure</th>
<th>Frequency/Percentage</th>
<th>Mean for Effectiveness Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Police power regulations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storm resistant building standards</td>
<td>(23) 58</td>
<td>4.17</td>
</tr>
<tr>
<td>Zoning</td>
<td>(19) 45</td>
<td>3.88</td>
</tr>
<tr>
<td>Subdivision regulations</td>
<td>(33) 83</td>
<td>3.70</td>
</tr>
<tr>
<td>Flood elevation requirements</td>
<td>(34) 91</td>
<td>4.43</td>
</tr>
<tr>
<td>Special hazard zone ordinance</td>
<td>(8) 27</td>
<td>4.10</td>
</tr>
<tr>
<td>Plans</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comprehensive plan</td>
<td>(16) 43</td>
<td>2.87</td>
</tr>
<tr>
<td>Storm component of comprehensive plan</td>
<td>(5) 14</td>
<td>3.60</td>
</tr>
<tr>
<td>Recovery plans and policies</td>
<td>(17) 46</td>
<td>3.20</td>
</tr>
<tr>
<td>Land acquisition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land acquisition for open space parks</td>
<td>(7) 18</td>
<td>3.60</td>
</tr>
<tr>
<td>Relocation of existing development</td>
<td>(4) 10</td>
<td>4.00</td>
</tr>
<tr>
<td>Public facilities location</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Location of public facilities outside hazard areas</td>
<td>(9) 23</td>
<td>2.86</td>
</tr>
<tr>
<td>Development incentives</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preferential taxation for open space uses</td>
<td>(2) 5</td>
<td>4.00</td>
</tr>
<tr>
<td>Density transfer from hazardous sites to less hazardous sites</td>
<td>(0) 0</td>
<td>n.a.</td>
</tr>
<tr>
<td>Hazard disclosures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hazard disclosure requirements</td>
<td>(10) 29</td>
<td>3.14</td>
</tr>
</tbody>
</table>

* When an emergency manager and a city planner responded from the same community only the response of the latter was used.

Comprehensive planning (43%) and recovery plans and policies (46%) were used by nearly half of the communities in their land use management programs. These planning measures were considered to be moderately effective in reducing storm risk. The remaining land use management measures, however, were used for less frequently (29% or less). These measures included a storm component of comprehensive plans, land acquisition and relocation schemes, public facility location and hazard disclosure requirements and development incentives. Of these remaining measures, relocation of
existing development (mean 4.00) and preferential taxation for open space uses (mean 4.00) were given high effectiveness scores for reducing storm risks while the other measures were rated as moderately effective.

Summary and Conclusions

The survey results discussed in this paper are based on preliminary findings of an ongoing study. From this initial analysis the following preliminary conclusions can be drawn. Of all emergency response measures employed by local governments during Hurricane Alicia, the procedure for accessing information about evacuation route cut-off times was the least effective. Procedures for finding equipment were the most frequently used emergency response measures, however, they were given low effectiveness scores. Of all land management measures, building improvement regulations were used most frequently and were given the highest effectiveness scores.

Note

The research for this paper was supported by the Texas A&M Sea Grant Program.

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RESIDENTS' AWARENESS OF THE COASTAL FLOOD HAZARD:
LOWER FLORIDA KEYS CASE STUDY*

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University of Wisconsin-Oshkosh

The rapidly growing coastal population's awareness of coastal flood hazards has become a topic of great interest to planners, civil defense personnel, and hazards researchers. The population within the coastal areas of the U.S. has not only been growing at three times the national rate, but most of this population lacks experience with coastal storm flooding.

This paper reviews the public awareness of the hurricane flood hazard in one of the most vulnerable areas of the United States, the Lower Florida Keys. This area, in which the highest elevation is a mere eight feet and in which over 90% of the homesites are below the five-foot contour, has experienced hurricanes in an average of one in seven years, although the last direct hit occurred in 1966. Furthermore, the minimum base flood elevation shown on the Federal Insurance Rate Maps for the area is nine feet, and it could take 31.5 hours to evacuate the Keys (Post, et al. 1983:117). Nevertheless, the population of the Florida Keys, excluding Key West, increased by 66% between 1970 and 1980. This paper summarizes the responses of approximately 700 recent home buyers to a survey conducted during the 1983 hurricane season and compares their attitudes with those expressed by nearly 200 long-term residents.

Awareness of the Hurricane Flood Hazard

Residents who purchased their houses or mobile home sites within the Lower Florida Keys since 1979 are generally aware that hurricane destruction may occur, with 60.6% believing that a damaging hurricane is "very likely" or "likely" within the next ten years. Furthermore, two-thirds of the residents felt that "hurricane

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waves and flooding" were either a "major problem" or "somewhat a problem" facing their households in living in the Florida Keys, although like residents of the Florida Panhandle (Baker et al. 1976:18), they anticipate that property damage would be more likely from hurricane winds than coastal flooding. Other problems were of greater salience to most recent home purchasers. For example, larger proportions of the survey population indicated that public water supplies, mosquitoes, and even hurricane winds were "major problems" than was the potential for hurricane waves and flooding. When asked to indicate the "single most important problem to their household in living in the Florida Keys," 80.1% mentioned conditions other than hurricanes, 11.0% claimed hurricane flooding; 7.5% hurricane winds; and 1.4% both hurricane flooding and winds. Indeed, everyday problems are of far greater concern.

Long-term residents (those who purchased their homes before the county adopted Ordinance 3-1975 which first required homes to be elevated above the base flood levels) were nearly twice as likely as recent residents to view this potential flooding as not a problem at all, although similar proportions considered hurricane flooding as a major problem. The concerns reported in 1983 by both the recent homebuyers and the long-term residents were, nevertheless, considerably greater than the responses of Lower Florida Keys residents in 1976 to the same survey question. Then 59% considered hurricane flooding as either a minor problem or not a problem at all (Cross 1980:157), while in 1983 only 32% of the new residents expressed such minimal concerns.

Respondents to the 1976 survey were resurveyed in 1982. Responses to the same questions showed a small overall increase in concern, with 47% claiming that hurricane flooding was at least somewhat a problem in 1976, compared with 53% in 1982. Individually, 64% of the respondents expressed different evaluations on the two surveys, with 37.5% indicating heightened concern and 26.7% expressing diminished concern.

The recent homebuyers' storm awareness does not reflect the high probabilities of storm flooding. Indeed, 21.5% believed that the Florida Keys are less likely to be hit by hurricanes, "compared with other locations along the Gulf and Atlantic coasts of the U.S.," while 68.6% thought that the area is equally likely to experience hurricanes. Furthermore, if a hurricane were to hit the area, only 34.9% of the respondents felt that it would be more likely to cause property damage than in other coastal locations, notwithstanding the area's very low elevation. Compared with other portions of the Florida Keys, the Lower Keys were viewed as either less
likely or equally likely to suffer damage by 90.3% of the new homeowners. Long-term residents and recent homebuyers did not significantly differ in their evaluations of the Keys' probability of experiencing hurricanes or vulnerability to damage should a storm hit, although long-time residents were more likely to feel that the Lower Keys were less vulnerable to damage than the Middle or Upper Keys.

Over one-third of the recent homebuyers were uncertain as to whether or not their homes were located within a designated hurricane flood zone, with 6.5% indicating that they were not. However, the entire study area has no natural elevations above the base flood levels, and 83% of the survey respondents' homes were on lots either along the shore or canals. Old and new residents did not differ in their knowledge of their own flood zone location.

If a hurricane were to directly strike the Lower Keys, 78.6% of the house owners and 94.7% of the mobile home buyers expect that their homes would suffer at least "moderate damage." Nevertheless, 37.0% of the house buyers, compared with 8.5% of the mobile home owners, believed that they could safely ride out such a storm within their homes. Furthermore, 23.4% of the households occupying houses and 6.4% within mobile homes indicated that if hurricane warnings were issued for their area of the Florida Keys, they would "plan to ride out the storm in their own Keys home."

Awareness and Adoption of Flood Mitigation Measures

The adoption of various flood hazard mitigation measures is now fairly high. Although realtors reported that homeseekers were often ignorant of flood insurance requirements when they began their home search, 74.5% of the recent house buyers and 62.9% of the mobile home owners had acquired flood insurance in 1983, up from 53% and 31%, respectively, in 1976. Only 56% of the long-time residents had insurance, however. Even among those new residents without home mortgages, and thus not legally required to obtain insurance, 66.5% had acquired flood insurance. Indeed, coastal flood plain residents are far more likely to have obtained flood insurance coverage than residents within river floodplains (Kusler 1983:7). Nevertheless, these figures were less than the 88.3% windstorm insurance coverage reported by recent homebuyers. Seventy-one percent of the residents acquiring their homes since 1979 selected stilt houses, compared with 37% of the households who purchased their homes in 1975 or earlier. Furthermore, 90.5% of the houses built since 1976 are upon stilts, with
most of the remainder being built upon fill. However, the additional safety for which stilt houses were promoted has been substantially negated by enclosure of the space beneath many of these homes, by what often cannot be considered break-away walls. Indeed, 40% of the over one thousand stilt houses constructed within the study area since 1976 have at least half their lower levels enclosed for storage, garages, and living space.

Flood protection was not the primary motivating factor in the choice of a home. When asked to indicate the importance of various factors in the selection of their homes, the home price, beauty of the neighborhood area, investment potential, crime rate, and particularly, access to deep water boating and nearness to shore or canals were all considered more important than elevation of the house above ground, the safety of home during a hurricane, or the vulnerability of the homesite to storm flooding. Even when realtors informed homeowners that houses were in a flood zone or that flood insurance might be required (a disclosure given to 49% of the home buyers since 1979), only 12.4% of the recipients indicated that it made any difference in their choice of home or homesite. The disclosures dissuaded few potential residents, with fewer than one in five realtors able to recount losing a sale because of the potential for hurricane flooding. On the other hand, the provision of hurricane flood zone information by the realtor or home seller was significantly associated with the homebuyers' flood insurance coverage, even with those residents lacking mortgages (Cross 1985).

Recent buyers of both houses and mobile homes generally favored the local flood mitigation regulations. Three-quarters of the residents felt the "present 8 feet minimum elevation requirements" were "about right," although they were "too restrictive" for nearly a fifth. Nevertheless the majority of the residents were in favor of the county using the new Federal Insurance Rate Maps (in preliminary form at the time of the survey) to set minimum elevation levels for new home construction, even though they require greater elevation with the inclusion of wave action effects.

Factors Associated with Coastal Flood Hazard Awareness

The environmental setting of the homesites, including their flood hazard zones (V vs. A Zones), base flood elevations, lot elevations, and proximity to the shore, were generally not associated with variations in the residents' evaluation of the Keys' vulnerability vis-a-vis other coastal areas, the expectation of a damaging
storm in ten years, the knowledge of their home's flood zone location, or the perception of hurricane flooding as a problem. However, residents, particularly owners of houses, whose homes were located along either canals or the shore were significantly more aware (60.1% vs. 42.1%) that their homesites were within flood zones.

The awareness that Lower Florida Keys residents have concerning hurricane flooding and their perception of this hazard as a problem are related to few socioeconomic parameters, not unlike observations among river floodplain residents (Smith and Tobin 1979:43). Indeed, the homeowners perception of hurricane flooding as a problem was not related to their age, income, educational level, or the sex of the respondent. On the other hand, recent home buyers who previously lived outside the South Atlantic states were more likely (29.3% vs. 20.3%) to consider hurricane flooding as a major problem. Residents migrating from other coastal counties had higher expectations that a damaging hurricane was "likely" or "very likely" within ten years. Furthermore, the expectations of a damaging hurricane were significantly related to the respondents' income and educational levels, although not to their age or sex.

Fifty-five percent of the post-1979 homebuyers claim to have experienced a hurricane. Although their descriptions of the events indicate that many of these experiences were with hurricanes which threatened and then missed the area or with tropical storms--similar to pseudo-experience reported by residents throughout southeastern Florida (Post, et al. 1983:61) and the Bahamas (Lewis 1975:29)--these experiences are related to their concerns about hurricane damages. Although experienced and inexperienced residents did not differ in their expectations of future hurricanes, larger proportions of the "experienced" residents claimed the Lower Keys were less likely to receive damages during a hurricane than either other U.S. coastal areas or the other areas of the Keys. Furthermore, 12.9% of the "experienced" residents claimed hurricane flooding was no problem at all within the Lower Keys, a claim made by only 6.6% of the inexperienced homebuyers. Experience has generally had a negative impact upon the residents' hurricane concerns. Thirty-five percent of those residents without hurricane experience claim to be more concerned about hurricane damages now than when they first began living in the Keys, a claim made by only 20.6% of the "experienced" residents.

Conclusions

These findings clearly indicate that coastal residents are highly aware of the
coastal flood hazard and are willing to accept many hazard mitigating adjustments. Indeed, their awareness and willingness to purchase flood insurance far exceeds that found within riverine floodplains. At the same time the awareness which these residents have raises many severe problems for planners. Just because they are aware of coastal flooding does not mean residents will faithfully maintain flood resistant housing or evacuate if urged, nor that they fully appreciate their risk. While residents' hazard perceptions change with time, it is not clear that experience leads to heightened awareness, particularly when minor events are construed as experience leading residents to underestimate their vulnerability to the rarer, but far more dangerous flood event.

References


THE VARIABILITY OF FLOODWAY ENCROACHMENT DETERMINATION

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Introduction

Designated floodways may be determined by any of several methods. This paper will treat the designated floodways as they can be determined from Corps of Engineers computer program HEC-2, Water Surface Profiles. This program is very powerful, well documented, and supported, which exemplifies why it is probably the most widely used backwater program in the world. Other commonly used computer methods are deemed to be similar to at least one of the several encroachment algorithms programmed into HEC-2.

The purpose of this paper is to elucidate the variability of designated floodways that might be determined by different investigators. The aspects of the nonuniqueness of designated floodways must be critically addressed since property values, land use, and municipal building permits are affected by the exact delineation of the left and right encroachment stations, which define the designated floodway.

Methods of Floodway Determination

The Hydrologic Engineering Center (HEC) has developed six different methods for establishing floodway encroachment stations using HEC-2. These may be briefly summarized below as:

METHOD ONE: An encroachment procedure which allows the program user to specify directly the desired encroachment stations (left and right). With this method, HEC-2 will determine the water surface elevation and other hydraulic data with the given fixed encroachment stations.
METHOD TWO: This procedure utilizes a fixed top width of encroachment whereby the left and right encroachments are made equidistant from the channel centerline, which is delineated by the left and right overbank stations. This method is useful to simulate the hydraulic effect of ordinances which provide a uniform flow easement centered on the stream.

METHOD THREE: This algorithm provides for a specified reduction (in percent) in the natural conveyance which is to be removed from the overbank areas. Normally, half of the specified conveyance reduction is eliminated from each side of the cross-section. There is also provision to reduce the conveyance in proportion to the distribution of the natural conveyance which occurs on each overbank. With this method HEC-2 determines encroachment stations as well as the resultant hydraulic properties of the floodway.

METHOD FOUR: This method computes encroachment stations so that the conveyance within the encroached cross-section (at a higher elevation) is equal to the conveyance of the unencroached (natural) cross-section (for the same discharge) at the natural water level. The encroachment stations are determined so that an equal or proportional loss of conveyance occurs on each overbank. A desired rise in the water surface elevation is specified, in this method.

METHOD FIVE: This method has the same goals as method four (i.e., determine encroachment stations given a target rise in the water surface elevation) except that a different algorithm is used. Method five uses the percentage reduction in conveyance as an objective function, which is optimized to determine encroachment stations. Equal or proportional conveyance reduction may also be specified.

METHOD SIX: The procedure is much like method five except, the energy grade elevation change is the targeted difference which is optimized. Method six was initially developed for applications involving steep streams in which encroachments by methods four and five often resulted in an encroached profile which has elevation lower than the unencroached (natural) profile.
A Critical Review of Each Method

Method one will provide a water surface elevation consistent with the conveyance that will be computed by the encroachment limits that are subjectively provided by input left and right encroachment stations. If a target increment of one unit above the natural water surface is desired, a trial and error procedure is necessary before an elevation difference of that one unit is ever achieved with method one. Actually, it is not likely that an exact targeted difference of any specified precise value is ever feasible even though possible. A better concept is to view any target-difference as a maximum value rather than an exact value that must be achieved. A tolerance, or range of values, would be more logical. Method one does not require that an initial unencroached profile be computed prior to the profile using specified method one encroachment stations. Actually, however, when determining floodway encroachments, an initial run using one of the automatic methods (methods four, five or six) should be made, and must be made if a known targeted water surface increment is to be achieved. It must be remembered, that no targeted increment is actually an objective method one algorithm, but exists only in the mind of the user. Sometimes, method one is the sole procedure which will yield the results at all cross sections that engineering judgement dictates to be reasonable and prudent in light of all the considerations. Method one does not require, nor is it restricted to, encroachment stations exterior to the left and right overbank stations. Most of the other methods (three thru six) are "overbank constrained" as will be seen later in this paper. It is obvious to even casual users of method one that an infinite number of answers are possible. This procedure does not require equal or partial removal of conveyance from either side. In fact, some of the channel itself can be used. However, the spirit of floodway designation is that logic and engineering judgement be applied. Unreservedly, any percentage of the conveyance can be removed from either side. Therefore, selfish, ruthless, or unethical application of method one procedures would favor a landowner on either side of the stream. Also, any changes in the floodway width at one cross-section will cause changes at cross-sections upstream. These changes may be adjusted until the desired result is achieved. Guidelines will be presented later in this paper to provide for this and other situations. Finally, method one can be prudently utilized to provide cessation of encroachment by one of the automatic methods, as may be necessary, or desired.
Method two makes sense in that if a floodway width could be somehow specified, estimated, or even legislated, then each encroachment station would be located at the same distance from the computed streambed centerline, as set up based upon the location of the left and right overbank stations. Method two is not overbank constrained, that is, the encroachment stations could properly be set within the channel itself, as far as the procedure itself is concerned. Thus, no provision is made that all of the channel area is retained as flow area. This method makes use no particular increment in the water surface elevation. In any flood study where an unimproved channel is studied, simply setting the top width seems inconsistent with consideration of the natural conveyance, flow distribution, or associated topographic features which must form a basis for delineating a logical floodway. In an improved channel or prismatic configuration, method two seems most appropriate. Simply setting the floodway at the upper channel overbank stations, even if they are high and dry, is most logical and has been used by the authors with acceptable results to everyone concerned.

Method three is perhaps a logical choice if the user has an estimate of the conveyance reduction percentage that might be appropriate. If the user had properly called for the HEC-2 flow distribution option, then an educated estimate of conveyance reduction and its division between left and right sides could be made. This method is infrequently used by most investigators but could be a valuable tool once experience in its utilization and application is achieved. Method three is one of the automatic methods in that encroachment station are uniquely set by the program.

Method four is perhaps the most widely used and most popular of all of the methods available for floodway encroachment determinations. This is so due to the output which is produced. Even though, a target water surface rise, of say, one foot, or any amount, is called for, experience shows that it will rarely be achieved at precisely that value. This is explained in the basic algorithm assumption that conveyance is a parabolic function of distance between data points in the overbank. This is appropriate as long as depth is constant, but is less exact as depth changes with station distance across the channel segments. Due to this inexactness, several profiles are usually computed with varying targeted water surface increments until the water surface rise computed is the one desired. Sometimes, there is just no
solution available that will achieve the target water surface elevation rise at a particular cross-section. In this event default encroachment stations would be set at the overbank stations. Method four is overbank constrained in that the encroachment stations can never be set within the channel. From a practical engineering point of view, this is highly desirable, and is in conformance with the floodway determination guidelines for flood insurance studies of the Federal Emergency Management Agency (FEMA). Thus, when an improved channel has been created, the encroachment stations are logically set at exactly the left and right overbank stations. Informed users of any encroachment techniques will realize, early, that some aspects of floodway designation are logical while others are simply a matter of engineering judgement.

Method four is deemed automatic in that no top width, or specified encroachment stations are specified. Realistically, one might take the best results from several runs using method four, and make a few final runs with method one to really sharpen the results numerically. A criteria for this procedure is set out later in this paper.

Method five has most of the characteristics of method four. It was developed later in the evolution of HEC-2 and is deemed by many to be a better procedure than method four. For riverine corridors where channel geometry is radical and topographically varying, perhaps this procedure is an improvement over method four. Experience will quickly show that sometimes this is so, and sometimes not so in striving for the target water surface elevation increment. Method five, like method four, requires an initialization (natural) profile to establish the natural conveyance prior to the floodway computation profile. Since method five employs an optimization procedure the length of time for computations and hence computer cost can be significantly greater than method four.

Method six operates similar to method five except that the optimization is based upon an incremental rise in the energy grade elevation rather than the water surface itself. The concept is that the energy grade line is a more stable criteria to meet. This might be particularly useful for larger energy gradients in high velocity streams. A natural profile is also required prior to the profile applying method six. Equal or proportional conveyance reduction may be specified for both methods five and six. A judicious application of method six will elucidate the fact
that several runs may be required to achieve a targeted increment. Users should be aware that with any of these methods, floodway velocities can increase significantly and water surface profiles may decrease. Decreases in water surface elevation are deemed unacceptable to most governing agencies, but are in fact a possibility in the real world.

**General Guidelines for Prudent Establishment of Encroachment Stations**

The general guidelines to be followed for establishing floodway encroachment stations which delineate the designated floodway are few in number, but important in scope and concept. A suggested compilation of essential criteria factors might be as follows:

1. That the hydrology and hydraulics be based upon existing conditions.
2. That the discharges be based upon one percent exceedance frequency.
3. That the flood plain will be divided into a central designated floodway and a floodway fringe area on each side of the designated floodway.
4. The designated floodway will pass the flood discharge without causing the water surface to rise by more than one foot (acceptable rise may be less in some states or communities) above the natural water surface elevation.
5. The floodway fringes are assumed filled solid for purposes of hydraulic computation.
6. That there should not be a significant increase in stream velocity.
7. That there should not be unreasonable depths in the floodway fringes.
8. That there should not be undulating top widths.
9. That the floodway should be consistent with local needs.
10. That the results should be consistent with engineering judgement.
11. That in improved channels where the capacity of that channel will carry the one percent exceedance discharge, the encroachment stations can be set at the channel overbanks where they will be high and dry, and meet all agency rules and regulations.
Conclusions

Whenever the natural floodway elevations have been determined by one of the preferred methods, the outer fringe lines can be drawn onto contour maps by those with engineering experience. The designated floodway stations cannot, however, be drawn in by the same procedure because no contour interpolation is possible. To mitigate some of the problems in accurately drawing the floodway onto maps a greater number of cross-section can be used, or engineering judgement be judiciously applied. In radically changing topography, this becomes virtually impossible and some of the above criteria must be applied. Certainly rugged topographic features and constancy of widths should be recognized. At any rate, these designated floodway encroachment stations are often a matter of opinion, and that opinion is hopefully rendered by competent engineers with great experience and good engineering judgement.

References

Federal Emergency Management Agency

U.S. Army Corps of Engineers
Optimal development of the floodplain requires information based on the integration of land use, topographic, socioeconomic, and hydro-meteorologic data. In most communities these data are stored on hard copy maps, graphs, and charts. The floodplain manager is faced with the complex task of keeping these data up to date, and also with converting these data into usable information. Today I am speaking about a technology for rapidly building and updating a community's floodplain information system.

The technology of which I speak is a product of NASA's Earth Resources Laboratory (ERL) at the National Space Technology Laboratories (NSTL) near Bay St. Louis, Mississippi. Since the early 1970's, ERL has been developing a software technology designed for the analysis of data collected by multispectral scanners flown on board Landsat satellites. The software modules are grouped in a broad package called ELAS, the acronym for Earth Resources Laboratory Applications Software. Satellite scanners are optical-mechanical devices which record the reflection of light energy from the earth's surface, and in doing so, produce an image. Multispectral scanners record data in two or more spectral bands, such as in the visible and infrared.

In support of NASA's scanning system research, ERL builds and tests simulator scanners to fly aboard aircraft. As a result, software designed specifically for integrating aircraft scanner data into a digital data base has been created.

In order to incorporate aircraft data into a digital data base, it must be accurately georeferenced. Because of the difficulties in maintaining an aircraft along a steady and even course, such a georeferencing program has to correct for data errors caused by flightline and altitude deviations. The ELAS module Rubber Sheeting, or RUBS for short, addresses these deviations.

Prior to running the RUBS module, the investigator selects an evenly spaced network of control points. Map coordinates and digital scan line and element
coordinates are identified for each control point. RUBS joins these control points into a network of triangles and georeferences within each triangle. Following georeferencing, the individual flightlines are ready for joining into one data plane. This data plane can be viewed on a cathode ray monitor for land use and land cover analysis. For example, the Southwestern Division of the U.S. Army Corps of Engineers has recently collected 5- and 10-meter resolution aircraft scanner imagery over a number of study areas. The Corps is utilizing this imagery for multi-purpose planning applications, such as flood control, lakeshore management, agricultural crop production, and documenting land use change over time.²

For the past two years ERL has investigated equipment which could be used to rapidly digitize map and photographic data. ERL recently obtained an Eikonixscan Model 78/99. This is a laboratory image digitizer which has a push-broom array scanner mounted behind a camera lens. For color scanning, color filters are placed in front of the lens. The array scans 2048 elements per scan line, advancing down the image one scan line at a time. The array configuration precludes skewing of the data, a problem common to video digitizers. By varying the size of the image scanned, the technician can vary the spatial resolution of the resulting data file. For example, if a 1:24,000 scale topographic map were scanned at one setting, the resulting data file would contain 2048 elements for each scan line. If the same topographic map were quartered, with each quarter scanned separately, the resulting data file can be subdivided into 4096 elements per scan line.

The image digitizer will be utilized in four ways. It will be used to digitize aerial photography, which can then be georeferenced with the RUBS module. These photographic data files will be used at ERL as a base for testing the accuracy of multispectral scanner classification software. The image digitizer will also be used to digitize isolines, such as mapped elevation data. Supporting software has been developed to classify these contour lines and to interpolate between these lines. A third use for the data will be to create digital areal imagery such as soil maps. Line-dividing software will blend the outlines which occur on published soil survey maps into the soil data file. A fourth use will be to digitize polygonal data. If, for example, the investigator required outline data, but not the areal data within the polygons, that areal data would be subtracted out.

While ERL is not in the business of mapping the nation's floodplains per se, spinoffs of ERL technology are directly applicable for that purpose. And, as private
industry is rapidly developing micro-systems which are affordable at the community level, this spinoff technology will find wide application. The message I want to leave you with is that the technology now exists for building and updating your community's floodplain information system. Land use maps can be rapidly updated and overlaid on Flood Hazard Boundary Maps, contour maps, zoning maps, and socioeconomic maps. These data files can be rapidly integrated to provide such information as the current land use within the 100 year floodplain.

References

NASA Earth Resources Laboratory
1980  ELAS Earth Resources Laboratory Applications Software

Earls, G.
MODELING UNSTEADY FLOWS IN LARGE BASINS: 
THE SANTA CRUZ EXPERIENCE

V. Miguel Ponce*, Zbig Osmolksi** and David Smutzer***

A case study modeling unsteady flows in a basin in the semiarid Southwest is presented here. The site is the Upper Santa Cruz River basin upstream of the Town of Marana, in the vicinity of Tucson, Arizona. The evaluation uses novel techniques of mathematical modeling in a data-intensive computational environment to calculate frequency-based flows at specific locations. A computer model capable of simultaneously handling the complex topology of the entire basin is driven by 100-year frequency rainfall events of 24, 48 and 96-hour durations.

Introduction

The use of computational methods to evaluate the hydrology of large basins is currently enjoying wide acceptance among practicing engineers and flood hydrologists. For basins exceeding 1000 square miles, the task of simulating flood flows by the computational method can be exceedingly complex. The estimation of hydrologic abstractions is difficult indeed, in light of the wide range of antecedent moisture conditions. However, other unresolved problems still remain, most notably the choice of spatial and temporal distribution of the input design storm, the channel routing parameters, and infiltration losses through the channel bed.

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The Basin

The Upper Santa Cruz River basin drains 3,503 miles in southeastern Arizona and northern Sonora, Mexico. At Tucson, the Santa Cruz River is joined by two major tributaries—the Rillito Creek and the Canada Del Oro—both located downstream of Tucson.

Precipitation varies greatly from year to year, with an annual average of 12 inches per year. Summer precipitation is usually of high intensity and short duration, resulting, as it does, from thunderstorms covering small areas. Winter precipitation is mainly the result of frontal activity, usually covering most of the basin with less intense but longer duration storms. Moisture from tropical depressions located off the Baja Coast of Mexico, combined with low pressure systems in Arizona, also supplies precipitation to the basin.

Most streams in the Upper Santa Cruz basin are ephemeral, being dry for long periods of time. Flow in such streams occurs only in direct response to precipitation, except in isolated cases. The streambeds are extremely permeable, and large amounts of water are lost to the subsurface as the flow moves downstream. The desertic conditions characteristic of the basin are highly conducive to quick runoff, but potential flood peaks are reduced by the relatively large capacity for streambed infiltration.

Case Study

The objective here is to evaluate the hydrology of the Upper Santa Cruz Basin, focusing in particular on the 100-year frequency floods at the Continental (Green Valley), Congress (Tucson), and Cortaro (Marana) USGS gages. These gages have 37, 80, and 44 years of non-continuous record and drain 1,682, 2,222 and 3,503 square miles, respectively. Prior to the October, 1983, flood event, the maximum USGS floods of record were 26,500, 23,700 and 23,000 cfs, respectively.

The Flood

During the last week of September, 1983, a low pressure system originating off the coast of California and a tropical storm moving in from the Gulf of Mexico combined to produce a steady, long duration, widespread rainstorm over southeastern Arizona. Rain gage records indicate that 6 to 8 inches of rain fell over the Santa Cruz and neighboring basins in the six-day period of September 28–October 3, 1983. The event was preceded by the wettest September of Record.

The heavy rainfalls triggered new record flows on the San Francisco River
at Clifton (132,000 cfs), the Gila River at Safford, and the Santa Cruz River at Tucson (52,700 cfs). Flood damage caused by the flooding of the Santa Cruz River and tributaries included severe bank erosion which led to structural damage to numerous bridges, the collapse of several homes and businesses which fell into the streams, and overbank flooding which inundated many homes with water and sediment. Overall damage estimates were in the neighborhood of $500 million.

Peak flows during the flood of October, 1983, were estimated by the USGS at 45,000, 52,700 and 65,000 cfs, for the Continental, Congress and Cortaro gages. Due to the washout of the gage during the flood, the Cortaro value is considered only an estimate.

The Model

The modeling approach consists of using a computational hydrologic simulation model to calculate peak flows at the three locations mentioned above, using rainfall events of 100-year frequency. Given the basin's size, the choice of stream channel routing method, and the spatial and temporal distribution of the input design storm and stream infiltration losses are considered the most critical modeling decisions.

Regional rainfall patterns indicate that for a basin of this size, it is necessary to consider both general and local storms. General (winter) storms are usually of low intensity but tend to cover most of the basin rather uniformly. Local (summer) storms cover only portions of the basin, but are usually of high intensity. Rainfall durations are selected to reflect the time of concentration for the entire basin for a 100-year frequency rainfall event. Accordingly, durations of 24, 48 and 96 hours are chosen for the storm simulations.

The model used in this study is a comprehensive modeling system to simulate the rainfall-runoff process in complex watersheds and stream channel networks. The user specifies the network in terms of a set topological numbers. Using this set, the model orders the calculations to enable the subwatershed hydrograph generation and the routing of flows through stream channels and reservoirs. The total basin area is subdivided into upland subwatersheds, which generate upland inflows to the stream network, and reach subwatersheds, which generate lateral inflows.

The model uses SCS methods for hydrograph generation for subwatersheds less than 6.2 square miles. The watershed lag time is based on the curve
number method (Soil Conservation Service, 1973). For subwatersheds greater than 6.2 square miles, the time lag is based on the time of concentration. The unit hydrograph duration is based on the time lag. The time-to-peak is based on the unit hydrograph duration. The peak flow is calculated by the SCS synthetic unit hydrograph formula. The synthesized unit hydrograph is convoluted with the effective storm pattern to generate the outflow hydrograph at each subwatershed outlet.

The stream channel routing module is a version of the comparatively recent Muskingum-Cunge method (Ponce and Yevjevich, 1978); therefore, it has the inherent advantage of being physically based. In actual practice, this means that the subreach parameter calibration which is necessary in conventional models (such as Hec-1 and TR-20) is all but eliminated. This enables the modeling of large basins at a level of detail hitherto only possible at a prohibitive cost.

Unlike the classic Muskingum, the Muskingum-Cunge method calculates routing parameters through local flow values, channel cross-sectional characteristics, and overall stream gradients. This enables the flood wave and flow variables, while circumventing the need for large amounts of historic data to ascertain ("calibrate") the values of these parameters. In this way, numerous yet accurate routings are possible.

A unique feature of the channel routing module is its capability to route flows with parameters which vary in time as a function of the local flow values. This is specially indicated for routing overbank flows, since the routing parameters are recalculated every time step to follow the rating curve more closely.

Channel transmission losses are accounted for in the subreach routing process (Ponce, 1979). This feature is particularly applicable to the Santa Cruz Basin where streambed infiltration constitutes an important component of the overall hydrology of the basin.

Data Requirements

The Santa Cruz Basin and stream channel network was configured into 119 reaches and 60 upland watersheds for a total of 179 subwatersheds. Each reach was assigned a topological number and each upland subwatershed a sequential number. Subwatershed areas, stream delineation, hydraulic lengths and stream slopes were evaluated using USGS 7.5' quadrangle maps. Coordinate data for 189 cross-sections was compiled from different sources, including actual field
measurements.

Soil and vegetation data were assembled from publications of the USDA Soil Conservation Service and the U.S. International Boundary and Water Commission. These data were evaluated for vegetative cover types, land use and hydrologic condition. SCS methods were used to determine a baseline set of runoff curve numbers. Base flows along the Santa Cruz Basin were considered to be negligible for purposes of simulating flood flows.

Baseline streambed infiltration rates were estimated based on a literature search. Matlock (1965) reported measurements in the range 2-10 ft/day along the Santa Cruz mainstem and for Rillito Creek. A tendency for the infiltration rate to increase with flow velocity--largely because of the higher heads associated with higher velocities and stages--and measured infiltration rates as high as 76 ft/day, but mostly under 20 ft/day. Average infiltration rates of 2-4 ft/day were chosen for the baseline set, to be adjusted during the calibration stage.

Rainfall data for the hindcast simulation included records for 31 gaging stations, spatially distributed throughout the basin. Data for 21 of the stations was hourly, and daily for the remaining ones. Point rainfall data obtained from NWS reference sources indicated that the 100-year frequency, 24, 48 and 96-hour duration storms are 4.6, 6.0 and 6.7 inches, respectively (National Oceanic and Atmospheric Administration, 1973).

Results

Hindcast, general and local storm simulations were performed using a time interval of 7.5 minutes. This interval time was judged to be adequate to satisfy the lag requirements of the smaller subwatersheds. A maximum subreach length of one mile was chosen to match the 7.5-minute time interval and guarantee the numerical consistency of the channel routing (Ponce and Theurer, 1982). The one-mile upper limit on the subreach length triggered the automatic generation of additional cross-sections, up to ten cross-sections per reach in certain cases.

Calibration runs showed the need for a downward adjustment of the curve numbers and an upward adjustment of the infiltration rates. After a series of trials, the values of 44,500, 56,900 and 83,000 cfs were simulated at Continental, Congress and Cortaro gages, respectively, for the October 1983 flood. To accomplish this, it was necessary to reduce the runoff curve numbers by 10 on the average, and to increase the infiltration rates up to five times.
the baseline values. In light of Woodward's findings (1973), the reduction in runoff curve numbers was deemed necessary to properly account for rainfall duration and corresponding basin size. The calibrated median runoff curve number was 76 and infiltration rates were in the range 2-20 ft/day.

Results of the general storm simulations indicate that the critical storms are of 24-hour duration. Peak values at Continental, Congress and Cortaro are 58,700, 45,600 and 55,600 cfs, respectively. These values were obtained by driving the model with low-intensity storm covering the entire basin. Results of the local storm simulations indicate that the critical storms are of 48 hours duration.

Peak values at Continental, Congress and Cortaro are 47,200 cfs, 67,000 cfs, and 47,800 cfs, respectively. These values are obtained by driving the model with high-intensity storms covering cells of approximately 400 square miles, critically positioned immediately upstream of the gages.

References


As the Federal Hazard Mitigation Coordinator for the two Major Presidential Disaster Declarations in Utah (1983 and 1984), one of my responsibilities has been to facilitate the development, coordination, and implementation of the recommendations of the Federal Interagency Hazard Mitigation Team. Coupled with another responsibility to provide technical assistance to the State of Utah for development of its State "406" Hazard Mitigation Plan, I have become increasingly familiar with the problems of floodplain management in an obscure area, fluctuating lakes.

As a partial consequence of three years of above normal precipitation and excessive groundwater, the Great Salt Lake has risen an unprecedented ten feet in two years. This rise has inundated 625 square miles of perimeter lands, creating enormous economic, political, social, and environmental impacts. Damage estimates to date exceed $176 million.

Although lake level fluctuations are not unusual, historical meteorological and geological records only provide limited indications of what is to come. As the Great Salt Lake continues to rise, it continues to destroy development, fluster its users, and challenge "the experts." Protective and preventive measures have been and will continue to be taken, but additional expected and unforeseen problems arise as quickly as the lake.

The geologic history of elevations for the Great Salt Lake is well documented for the past 25,000 years. Actual recorded historic data, however, date back only to Fremont's observations in 1843. The first gage was installed in 1875. Since that time numerous minor fluctuations have been observed.

Having established that fluctuations of the surface elevation of the Great Salt Lake are not unusual, or unlikely, it logically follows that the astronomical damages resulting from the lake's current level are the result of man having developed in a known hazardous location. At present, damage has occurred to Interstate 80, the numerous mineral extraction industries, private, State and Federal wildlife refuges, power transmission towers,
State parks, privately owned resorts, two railroad lines, sewage treatment plants, and housing. Potentially, Salt Lake International Airport and the new International Business Center could be affected. The impacts of this lake rise would be even greater in the absence of the existing consumptive uses (agricultural use of inflow, reservoir retention, and evaporation ponds).

In response to the most recent lake rise, all levels of government have been intensely involved. At the Federal level, the Federal Highway Administration has funded the raising of portions of Interstate 80. The U.S. Army Corps of Engineers has participated in the diking of several sewage treatment plants. The National Oceanic and Atmospheric Administration has maintained precipitation, river inflow, and lake level prediction data. FEMA will be providing funding for the replacement/restoration of publicly owned damaged facilities, and has maintained a coordination role for the Federal agencies' activities. The Bureau of Reclamation has repaired damaged dikes along Willard Bay. The U.S. Fish and Wildlife Service has diked the Federal migratory bird refuge. The Federal Interagency Hazard Mitigation Team has offered both short and long-term recommendations to all levels of government on how to minimize present and future impacts of Great Salt Lake flooding.

State government has been involved in numerous mitigation projects as well. The Utah Department of Transportation participates in the protective work along Interstate 80, as well as many other inundated roads. The Division of Parks and Recreation has attempted to protect the public parks, beaches, and islands. The Division of State Lands and Forestry, the State Engineer's Office, the Division of Water Resources, the Utah Geological and Mineral Survey (all within the Department of Natural Resources) have performed monitoring and reporting functions, as well as funding at least 17 different studies and plans for immediate response and long-term management of the lake. The State legislature has provided the necessary funding for these projects.

Counties have been involved with selected diking and pumping projects, as have private land developers. The universities and State and Federal agencies have directed selected efforts at improving forecasting techniques in an attempt to reduce the "window of probability" that future lake levels could be expected to fall within. Present predictions are for the lake to peak at 4210.25 this year, and even higher in 1986.

Valuable lessons in the floodplain management of fluctuating lakes have been learned in the process of responding to, postulating about, planning for, and recovering from the recent rise of the Great Salt Lake. It is important to take note not only of what information has been gained, but also those areas where it appears we have learned nothing. By assimilating and assessing these data sets we better prepare ourselves for similar problems occurring elsewhere, or those that have yet to appear.

Quite simply, we have learned about the enormity of the problem of fluctuating lakes, and the multivariate implications caused by the conflicting land uses in areas that are subject to occasional, repetitive inundation. Scientific investigations into forecasting techniques have led to discussions of El Nino, El Chichon, tree rings, sunspots, groundwater,
run-off, precipitation, evaporation, lake effect, drainage, and consumptive use. Economic impacts have affected all levels of government, industry, and private individuals. Multi-jurisdictional political interests are forced upon each other. For example, the Great Salt Lake lies within five different counties, each with their own particular interests, tax base, and set of constituents.

We have also learned of the expanded uses of specific scientific instrumentation and information. There has been identification of new needs to which existing technologies can be applied. There has been the identification of further potential impacts in a host of areas through economic impact studies.

Unfortunately, it is apparent that there are lessons that we have yet to learn.

[As we know] "The Great Salt Lake lies at the bottom of a closed basin. Due to the wide range of inflow to the lake, the surface level, surface area and volume of the lake has experienced wide fluctuations in the recent past. Efforts have been made to predict future levels of the fluctuations to avoid problems of development around the lake that would be damaged by high lake levels. Recent studies have predicted levels to elevation 4212 in the near future. The general consensus of researchers and climatologists is that such predictions cannot yet be made with any degree of assurance. The data should, however, serve as a warning that the lake could rise to levels that would cause considerable damage to new and existing development around the Lake."

These are the exact words of Lloyd Austin, Division of Water Resources, Utah Department of Natural Resources, in an abstract to his paper, "Lake Level Predictions of the Great Salt Lake." Written in 1979, his words provide an indication of how well his advice has been heeded. Here we are, six years later, repeating the same concerns.

Another point can be made that, even with the recent (past five years) emphasis on nonstructural floodplain management techniques, the only serious response plans considered have been structural, primarily west desert pumping schemes, selective protective diking, and upstream retention and/or diversion. Even the proposed long-term management strategies are based on structural alternatives. These plans merely address lakeshore uses at particular lake level elevations. When all response plans are prefaced by, "From an engineering point-of-view" (inferring a structural response), one cannot help but to think we have a flat learning curve.

I find it ironic that the Southern Pacific Railroad, whose tracks cross the Great Salt Lake on the causeway that contributes to south shore flooding, owns another set of tracks that have been submerged since 1907 beneath the Salton Sea; another fluctuating inland desertic saline terminal lake.
Most important though, we have learned that the rise of the Great Salt Lake is not an unusual event. Across the United States we have found that fluctuating lakes are not unusual. There are documented cases of repetitive flooding from fluctuating lakes in Oregon, California, Utah, North Dakota, Minnesota, New York, and in areas around the Great Lakes. What is disturbing is to find that there has been no semblance of an established methodology, at any level of government, for responding to and planning for these events.

FEMA Region VIII, along with the Natural Hazards Research Applications and Information Center in Boulder, Colorado, are jointly planning to document the responses to these events in order to provide a basis for consistent future policy decisions.

For now though, it is time to institute and implement long-term management strategies for the Great Salt Lake. This event, though unprecedented in its frequency to recur, should not be the problem it is. The problem is not that the Great Salt Lake goes up and down, or that Utah has experienced consecutive years of abnormal precipitation, but that Man has allowed development to occur where maybe he shouldn't have. We accept a certain degree of risk with everything we do. If what we are experiencing now is the risk accepted in the past, then fine, accept it. But let's not make the same mistake twice. Two years from now, or whenever the lake recedes, a long-term strategy should be in place, and enforced. We should define what risk is acceptable to highways, airports, wildlife areas, recreation facilities, private housing, sewage treatment plants, mineral extraction industries, and business and industrial parks, and then direct our future efforts toward operating within those parameters.

* * *

June 1985 Update:

The Great Salt Lake is at its highest level since 1877. On May 21, the lake's elevation peaked at 4209.95 feet ASL. This is 1.6 feet higher than last year at the same time. Since December, Utah has experienced a dry weather pattern with below normal precipitation. Temperatures have been warm and evaporation has increased.

In February, the legislature passed Senate Bill 97 which appropriated $96 million; $20 million to be used for flood mitigation projects and studies and $76 million to be held in a flood mitigation reserve account. One of the lake management options that the legislature is considering is the West Desert Pumping Project. This approach has been determined to be the most effective method to lower the lake level. Four to six pumps would be installed which would pump water from the south arm of the lake through an intake canal to the west pond where the majority of evaporation would occur. The water would then pass through an overflow canal into the east pond. After evaporation, the more concentrated brine would flow by gravity through a canal into the north arm of the lake. In addition to the pumps, dikes would be constructed to protect the Southern Pacific Railroad, the Bonneville Salt Flats, and the Air Force flight training area east of the west pond. Construction of the pumping project would take 15-18 months and
cost approximately $52 million. Yearly operation costs would be $4 million. The pumping project would maintain the lake elevation below 4212 feet. During the first year of operation it is estimated that the project would lower the lake by 16 inches. An Environmental Impact Statement is being conducted on the project and should be completed this fall.

Questions have been raised as to the economic feasibility of such a plan. Construction and maintenance of the West Desert Pumping Project are very expensive propositions. It will take 15-18 months for the purchase and installation of special saltwater pumps; by then the lake may be receding. The frequency of the abnormal weather conditions that Utah has experienced the last three years is expected to occur less than once every one hundred years. Concern has been expressed by the State legislature's Energy, Natural Resources and Agriculture Study Committee about private landowners, private roads, mining, and oil claims in the project area. It was also unclear how the brine re-entry into the north arm of the lake would affect mineral extraction industries around the lake, particularly those located on the south shore. For these reasons, alternatives should be carefully considered.

As a nonstructural method to address the lake's rise, the 15-Day Interagency Hazard Mitigation Report recommended the use of a working elevation of 4217 feet for planning and design activities. Scientists at the conference on "Problems of and Prospects for Predicting Great Salt Lake Levels" held in March 1985, also endorsed this recommendation. The State "406" Hazard Mitigation Plan is addressing this issue and is recommending the formation of an Intergovernmental Beneficial Development Council to establish a strategy for planning and development in the Beneficial Development Area, the area between the shoreline and 4217 feet. Meetings were held with State policymakers to brief them on such a proposal. The Great Salt Lake Tech Team, within the Department of Natural Resources, also made this recommendation at their April 18 meeting. They felt that the State should work with the counties to define the floodplain, consider it a hazard area, and plan accordingly. FEMA has informed the State of Utah that damages from future flooding of the Great Salt Lake may not be eligible for Federal Disaster Assistance under PL 93-288.
THE DEVELOPMENT OF RESIDENTIAL STAGE-DAMAGE CURVES FOR APPLICATION IN WESTERN CANADA

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IBI-Group, Calgary

Augusto R. V. Ribeiro
ECOS Engineering Services Ltd., Edmonton

Introduction

Flood damage estimates are required for evaluating the cost effectiveness of projects designed to alleviate flood impacts. In the past, flood damages have been examined by virtue of three basic techniques: 1) the first entails an examination of the flood plain immediately after the water recedes; if such estimates were available for every flood over a period of many years, a damage-frequency curve could be created; 2) an alternative method is to determine the damage caused by three or four recent floods whose hydrologic frequency can be determined and a smooth damage-frequency curve plotted through these points; 3) the third method entails hydrologically determining various flood elevations for specific flood frequencies and deducing synthetically the damages that would occur given these flood events. This analysis provides a synthetic damage-frequency curve from which one can estimate average annual damages for a given study area. The latter method is the one most frequently utilized primarily due to a number of limitations inherent in the first two techniques, the most critical being that for most flood plains, changes in land use with calendar time prevent the direct usage of a damage-frequency relationship based on historical damages.

Residential stage-damage relationships are an essential component of overall damage estimates. The depth of water above or below the first floor is the most critical estimator of flood damage to the structure and contents of residential buildings. There are several approaches which have been employed to develop residential stage-damage relationships in Western Canada. These are briefly described hereinafter.
Past Studies

The Templeton Curve was developed from actual flood damages incurred as a result of the devastating Winnipeg Flood of 1950. A single generalized curve was derived based upon a fixed percentage of the market values of the structures affected.3

A 1975 study of the Fraser River, British Columbia, by the Department of the Environment,4 estimated damages employing a classification system for categorization of residential units; however, they did not develop a representative stage-damage function for each class and instead employed a fixed stage-damage function based upon the Squamish River Flood Study.5 Contents were evaluated at 40% of the market cost of the building based upon information provided by the Canadian Underwriters Adjustment Bureau.

IBI/ECOS in a 1980 study of flood damages in Swift Current, Saskatchewan employed the Acres classification system,6 for determining residential unit types, and indexed stage-damage curves.7 These synthetic curves of unit depth-damage relationships for residential structures and contents were developed for the Joint Task Force on Water Conservation Projects in Southern Ontario in 1968 by Acres. The Curves were derived from field surveys of a representative sample of various unit types located within the City of Galt (Cambridge).

Stage-damage curves produced by the Federal Insurance Agency in the United States, (FIA Curves), which are premised on actual flood damage claims by unit type, have been employed on a number of other flood damage reduction studies undertaken in Alberta.8,9

The Fort McMurray Flood Damage Reduction Study

In 1981 the Alberta Department of the Environment, which is the provincial agency responsible for the management of water resources, initiated a comprehensive study of flood damages for the City of Fort McMurray in northeastern Alberta. A subsidiary objective of the study was to develop stage-damage curves that could be applied on future flood damage studies undertaken throughout
Alberta. An important component of the study was the evaluation of past estimation techniques. This review raised a number of concerns regarding use of these data: 1) With respect to the FIA Curves, there is no adjustment factor developed for application to Canadian situations. As well, this approach requires individual market appraisals of each unit and finally, basement damage is not adequately considered; 2) Regarding the Templeton and Acres data, this information was 30 and 16 years old respectively; needless to say, construction techniques as well as content types and distributions had changed considerably since the curves were initially developed. In addition, these data sources did not adequately consider different housing types i.e. 1 storey, 2 storey, split-level, etc.

Context
The City of Fort McMurray, with a population of 34,000 people, is located at the confluence of the Athabasca and Clearwater Rivers in northeastern Alberta. The oldest developed areas of Fort McMurray, the Lower Townsite and Waterways, are situated in the floodplain of the Clearwater River and have a history of flooding which dates back to 1835. The severest flooding is associated with the occurrence of an ice jam on the Athabasca River and the last major flood in 1977, which approximated a 1:17 year event, caused damages in the order of 20 million dollars.

Inventory of Residential Structures
A total of 3,341 residential units were inventoried and classified according to basic quality (A, B and C) and unit type (1 storey, 2 storey, split level). The classification system (See Exhibit 1) was also expanded to reflect several categories not addressed in previous studies i.e. mobile homes and multi-family dwellings.

Content Damage Curves
Individual content damage curves were derived for each classification and unit type based on a detailed contents survey of a statistically significant number of residential structures. The survey was directed toward obtaining up-to-date total depreciated contents per residential category. Survey questionnaires were operationalized for easy computerization and a content damage program was developed. The extent of direct flood damages to various objects as well as
restoration costs for flood damaged items were determined through consultation with experienced service and repair establishments. Ninety-five percent (95%) confidence limits were calculated for each structural type and for the overall sample of 124 units. The 95% confidence limits for the various structural types ranged from ± 11.7% to ± 26.6%. However, the 95% confidence limits for the entire sample were ± 8.6% of the mean total content value (See Exhibit 2).

EXHIBIT 1.
FORT MCMURRAY RESIDENTIAL CLASSIFICATION SCHEME

<table>
<thead>
<tr>
<th>Class</th>
<th>General Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aw* 1</td>
<td>Typical custom constructed housing built, for the most part, during the 1970's architecturally designed with control of materials selection and consideration of increased insulation values, use of controlled ventilation systems, interior materials, finishes and general design reflect an above average upgrading to the personal requirements of the owner. These homes represent the high end in terms of real estate values.</td>
</tr>
<tr>
<td>Aw 2</td>
<td>Typical subdivision construction of the 1960's, constructed by the developer or builders from a selection of stock design plans in accordance with design guidelines for exterior materials control. Exterior materials are typically aluminum and wood siding, stucco and brick veneer. The size of the unit, style and lot size set the average real estate value. These homes have average insulation values and represent middle real estate values.</td>
</tr>
<tr>
<td>Aw 3</td>
<td>Typically constructed during the 1950's to 60's, units are of average design, less than average of (1982), have a low level of insulation values, no vapor barrier or vapor seal and generally have interior finishes of wood siding and stucco. Generally, these units are located in the core area have a high land to building value ratio and represent the lower end real estate value. Many units will have upgraded interior finishes.</td>
</tr>
<tr>
<td>Aw 4</td>
<td>Mobile Home, Double Wide - Good Quality</td>
</tr>
<tr>
<td>Aw 5</td>
<td>Mobile Home, Double Wide - Poor Quality</td>
</tr>
<tr>
<td>Aw 6</td>
<td>Mobile Home, Single Wide - Good Quality</td>
</tr>
<tr>
<td>Aw 7</td>
<td>Mobile Home, Single Wide - Poor Quality</td>
</tr>
<tr>
<td>Aw 8</td>
<td>Mobile Home, Single Wide - Poor Quality</td>
</tr>
<tr>
<td>Wa</td>
<td>Apartment Towers</td>
</tr>
<tr>
<td>Ww</td>
<td>Walk-up Apartments, Row Townhouses</td>
</tr>
</tbody>
</table>

*1,2,3 denotes 1 storey, 2 storey and split level respectively

EXHIBIT 2.
MEAN TOTAL CONTENT DAMAGE BY STRUCTURE TYPE

<table>
<thead>
<tr>
<th>Structural Type</th>
<th>Mean $ (1982)</th>
<th>Standard Deviation</th>
<th>Sample Size</th>
<th>95% Confidence Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BW</td>
<td>5983.56</td>
<td>2627.34</td>
<td>34</td>
<td>± 11.7%</td>
</tr>
<tr>
<td>CW</td>
<td>4703.28</td>
<td>1936.11</td>
<td>26</td>
<td>± 17.8%</td>
</tr>
<tr>
<td>DW</td>
<td>5594.70</td>
<td>2999.32</td>
<td>21</td>
<td>± 17.2%</td>
</tr>
<tr>
<td>MW</td>
<td>4838.30</td>
<td>2106.89</td>
<td>13</td>
<td>± 25.4%</td>
</tr>
<tr>
<td>Mw</td>
<td>3635.20</td>
<td>1170.49</td>
<td>20</td>
<td>± 2.2%</td>
</tr>
<tr>
<td>ALL</td>
<td>5505.40</td>
<td>2608.73</td>
<td>124</td>
<td>± 8.6%</td>
</tr>
<tr>
<td>BW,CW,DW,MW</td>
<td>5665.95</td>
<td>2721.04</td>
<td>111</td>
<td>± 8.2%</td>
</tr>
</tbody>
</table>

Structural Damage Curves

The structural characteristics of residential units in each class were determined through field inspection by qualified architectural personnel and consultation with the local building industry. For each unit type, average square footage, perimeters, length of interior walls and types of finishes were calculated. Estimates of unit prices for replacing and/or repairing flood damaged materials were obtained from local suppliers and contractors. Based on the house characteristics and unit prices, damage for each foot of flooding was estimated for each unit type within the three basic categories (A,B, and C).
Comparison of Damage Curves

As part of the overall analysis, a comparison was made between stage-damage functions developed for previous investigations of flood damages, as discussed, and those developed specifically for the Fort McMurray Study. (See Exhibit 3). Damages were generated for the study area using the various curves. The following are the major observations of this analysis: 1) average annual damages employing the Fort McMurray Curves (IBI/ECOS) are significantly higher than those utilizing the other curves. This is directly related to substantially higher contents damages sustained at lower flood levels; 2) as average annual damages are highly sensitive to the stage-damage relationship, curves that do not accurately depict this relationship (FIA, Fraser, Templeton) could be grossly underestimating damages. While the Acres Curves approximate the Fort McMurray distributions, total damages indexed to 1982 values were substantially lower due to significant changes in residential content types, values and distribution since these curves were developed in 1968.

Conclusions

A number of major conclusions were drawn from this study as follows: 1) For most Western Canadian situations the previously developed stage-damage curves (Acres, FIA, Templeton and Fraser River) are not expected to render accurate assessments of damages for benefit-cost purposes; 2) Additional surveying of residential units from various sized centres across the Western Provinces should be undertaken in an effort to develop regional stage-damage curves; 3) In the absence of this data it is proposed that with indexing to account for regional and provincial economic differences the curves developed for Fort McMurray could be applied throughout Western Canada; 4) Unit stage-damage relationships should be updated at regular intervals to ensure they accurately reflect current trends and conditions.
References


ASSESSING FLOOD CONTROL BENEFITS IN LAKE FLOODPLAINS--
A DYNAMIC PROCESS

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CH2M Hill
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Salt Lake County Flood Control Office
Clyde Naylor
Utah County Engineer's Office

Introduction

During 1982, 1983, and 1984, unusually high precipitation produced exceptionally large flows into Utah Lake. The lake drains through a gate structure into the Jordan River that, in turn, flows through an urbanized area of Salt Lake City into the Great Salt Lake. The control structure was built more than 100 years ago to add storage in the lake for summer irrigation. It has also been used to constrain Jordan River flows, thereby reducing flood damage along the river. During the last three years, the lake level rose to record levels. This resulted in flood damages exceeding $20 million and inspired local agencies to investigate three flood control measures: 1) a new outlet control structure, 2) dredging to increase the Jordan River channel capacity, and 3) a new operational plan for lake releases.

In the study described in this paper, the economic feasibility of these three flood control measures was evaluated by estimating the benefits from the alternatives for each measure. A stage-damage curve was developed and used for this purpose. The dynamic nature of stage-damage curves used in assessing flood control benefits in the Utah Lake and other lake floodplains is specifically addressed.

Riverine Stage-Damage Curves

The damage caused by a riverine flood depends primarily on the maximum flood stage. Consequently, stage-damage curves are developed to estimate flood damages corresponding to a peak water surface elevation.
People respond to flood events during three stages: 1) warning, 2) inundation, and 3) recovery. The Water Resources Council (1979) identified three separate classifications of flood-induced costs associated with these stages: 1) protective costs involving emergency measures between the warning and inundation, 2) income losses during inundation until the property can be used again, and 3) repair costs for restoring property to its original state after the water recedes. The three are often summed to estimate flood damages, but economists (Milliman, 1984) have cautioned against double counting where these classifications overlap.

For river flooding, the first two stages (warning and inundation) are relatively short and most of the damages are associated with repair costs. The relationship of repair cost to river stages can be readily expressed in a stage-damage curve. For a given flood frequency, one can estimate the flow, stage, and the damage. By repeating the process, damages can be plotted against frequency, with the area under the curve then used to estimate average annual flood damages on a probability-weighted basis.

Dynamic Stage-Damage Curves for Lake Flooding

For lake flooding, the warning and inundation stages can take place over a period of months or even years, allowing plenty of time to construct protective measures and, for unprotected property, causing extended periods of income loss. Nevertheless, a stage-damage curve can still be applied. By starting with initial conditions, a stage-damage curve can be constructed for the current year. During that year, individuals will respond to rising lake levels and/or the threat of flooding by protecting their property. They may also have damages when forced to abandon their property or when their protective efforts fail. At the end of the year, certain protective measures will have been implemented and capital damages (repair costs) incurred, and the lake will be at a new stage. At that point, a different set of damages will be associated with the same range of stages. The stage-damage curve must therefore be adjusted to reflect these new conditions before going on to estimate the damages for the next year. An example of this adjustment is illustrated in Figure 1.

Simulation provides one tool for adjusting stage-damage relationships annually. Flood damages for lake floodplains (James et al., 1985) and frequent riverine flooding (Breaden, 1973) can be simulated by combining decision rules on property protection, abandonment, and repair with different sequences of
POTENTIAL DAMAGES (MILLIONS OF DOLLARS)

Source: Bureau of Economic and Business Research, University of Utah, December 1983 and August 1984

ESTIMATE AS OF DECEMBER 1983

REVISED CURVE (AUGUST 1984)

WATER ELEVATION

GREAT SALT LAKE STAGE-DAMAGE CURVE FOR SELECTED PROPERTIES (CAPITAL DAMAGES ONLY)

FIGURE 1

4205 4207 4208 4209 4210 4211 4212 4213 4214 4215 4216
flood events. The lake flood levels can be either deterministic forecasts or stochastic sequences (Chadwick, 1985; Bowles and James, 1985) of inflow, precipitation on the lake, and evaporation combined to generate new water surface elevations. The decision rules can also be deterministic or contain a stochastic element to represent the uncertainty of property owner response to lake level rises.

Developing weather scenarios and their corresponding decision rules is another method of simulating the dynamics of the stage-damage relationship. This is basically a simplified version of the simulation technique noted above. Weather scenarios should be selected to cover the range of possible inflow, precipitation, and evaporation conditions, and require a different set of stage-damage curves for each scenario. The closer these curves can represent the dynamic protection and abandonment decisions of property owners during lake level rises, the more reliable they become as damage estimators.

Whether the probabilistic simulation or the weather-scenario technique is used, annual adjustments to the stage-damage relationship are necessary to represent the changing damage potential on the floodplain. Sensitivity analysis can be used to determine how changes in property owner responses, lake levels, or other parameters would affect study conclusions.

Utah Lake Stage-Damage Curves

Figure 2 outlines the flood-prone and levee-protected areas at Utah Lake. The outlet control structure noted in the figure has a limited capacity and flow is further constrained by an operating policy incorporating legal and political agreements established to protect irrigation water supplies. This, along with the inadequate channel capacity of the Jordan River, has prevented sufficient water releases to keep the lake below flood stage the last several years.

An initial stage-damage curve was developed to reflect conditions on the Utah Lake floodplain in the summer of 1984. The first step in this process was to use aerial photos to determine areas inundated at the peak of the 1983 flood. Elevation contour lines from USGS maps were then used to determine areas that would be inundated at water surface elevations of the nearest contour lines above and below the level of the 1983 flood (i.e., 4490 and 4500 feet). A land use study of these potential flood areas determined the acreages and types of crops grown, the acreage of native vegetation, and the endangered residential, commercial, and industrial areas. Areas expected to be protected
Figure 2

Utah Lake - Existing and Proposed Levels.

Flooding and Potential Flooded Areas.
FIGURE 3
UTAH LAKE INITIAL STAGE-DAMAGE CURVE

EXPECTED DAMAGES (MILLIONS OF $)

STAGES (FEET ABOVE MSL)

COMPROMISE (4486.3)
1983 PEAK (4484.3)
1984 PEAK (4484.7)

Uta./Lahe
Ito ,

Jordan
River
Table 1
POTENTIAL FLOOD DAMAGES AT UTAH LAKE
FOR VARIOUS WATER SURFACE ELEVATIONS
(Thousands of Dollars)

<table>
<thead>
<tr>
<th>Type of Damage</th>
<th>$493.0</th>
<th>$494.3</th>
<th>$494.7</th>
<th>$495.0</th>
<th>$496.0</th>
<th>$497.0</th>
<th>$498.0</th>
<th>$500.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cost of Levees&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0</td>
<td>$2,566</td>
<td>$3,899</td>
<td>$15,895</td>
<td>$15,895</td>
<td>$29,224</td>
<td>$29,224</td>
<td>$29,224</td>
</tr>
<tr>
<td>2. Repair of Roads, Bridges, and</td>
<td>0</td>
<td>554</td>
<td>603*</td>
<td>639*</td>
<td>761*</td>
<td>883*</td>
<td>1,004*</td>
<td>1,248</td>
</tr>
<tr>
<td>Channel Siltation&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Agricultural&lt;sup&gt;d&lt;/sup&gt;</td>
<td>438</td>
<td>603</td>
<td>698*</td>
<td>769</td>
<td>1,007*</td>
<td>1,245*</td>
<td>1,483*</td>
<td>1,958</td>
</tr>
<tr>
<td>a. Crop and Land&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Buildings &amp; Improvements&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>53</td>
<td>142</td>
<td>272</td>
<td>583</td>
</tr>
<tr>
<td>4. Residential&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>17</td>
<td>76</td>
<td>183</td>
<td>653</td>
<td>1,312</td>
</tr>
<tr>
<td>a. Flood Damage&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>122*</td>
<td>144*</td>
<td>166*</td>
<td>210</td>
</tr>
<tr>
<td>b. Groundwater&lt;sup&gt;f&lt;/sup&gt;</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>53</td>
<td>53</td>
<td>53</td>
<td>53</td>
<td>53</td>
</tr>
<tr>
<td>5. Flood Fight, Private Homes&lt;sup&gt;g&lt;/sup&gt;</td>
<td>0</td>
<td>175</td>
<td>177*</td>
<td>178*</td>
<td>182*</td>
<td>187*</td>
<td>191*</td>
<td>200</td>
</tr>
<tr>
<td>6. Recreation Revenues&lt;sup&gt;h&lt;/sup&gt;</td>
<td>0</td>
<td>175</td>
<td>177*</td>
<td>178*</td>
<td>182*</td>
<td>187*</td>
<td>191*</td>
<td>200</td>
</tr>
<tr>
<td>7. Miscellaneous (@ 15%)</td>
<td>66</td>
<td>585</td>
<td>807</td>
<td>2,649</td>
<td>2,722</td>
<td>4,809</td>
<td>4,957</td>
<td>5,218</td>
</tr>
</tbody>
</table>

<sup>a</sup>Damages are assumed to be zero at compromise level (elev. 4489.34).
<sup>b</sup>CH2M HILL estimates.
<sup>c</sup>Based on historical damages.
<sup>d</sup>Excludes areas protected by levees.
<sup>e</sup>Based on Corps of Engineers' data.
<sup>f</sup>Reflects the lesser of protection costs or damages.
<sup>g</sup>Ring levees in areas south and west of Lehi.
<sup>h</sup>Based on county estimates.
<sup>*</sup>Indicates number was derived by interpolation.
by existing or new levees were not included in these estimates.

These data were used with information on historical damages, engineering cost estimates, field surveys, and consultations with public, governmental, and local authorities in estimating damages for various types of property. Some of the general rules used in estimating annual damages for this initial and subsequent-year curves were:

1) Protective costs were counted as a damage and estimated by an engineering cost analysis for necessary protective measures.

2) Income losses associated with temporarily or permanently unusable property were counted as damages. Operations that were discontinued or forced to shift to a less profitable location were also included.

3) Repair costs included only those occurring in the current year. Costs associated with previously destroyed or damaged property were excluded because the same degree of damage cannot occur twice unless the property had been repaired. In most cases, this had not happened.

The results for the initial curve are depicted in Figure 3 and summarized in Table 1.

Once the initial curve was completed, three weather scenarios were then developed to reflect a range of possible future weather patterns. These included "worst-case," "best-case," and "most-likely-case" scenarios. Sets of stage-damage curves corresponding to these scenarios were then derived from the initial curve. Adjustments were made to account for the previous year's damages and to reflect other changes, including those to endangered facilities, lake levels, and various decision rules. Adjusting the decision rules involved forecasting the protection strategies that corporate and public entities would follow. This was a critical step in the analysis.

**Flood Control Benefits**

It was readily apparent that the flood control measures would yield very few benefits for the best-case scenario in which the weather returned to a long-term normal or dry pattern. The focus was on benefits that would occur if the abnormally high precipitation were to continue, as in the most-likely and worst-case scenarios. These two scenarios were defined as 1) a continuation of inflow to Utah Lake at approximately 1984 levels for the period 1985-87
Table 2
FLOOD CONTROL BENEFITS
WITH TWO WET-WEATHER SCENARIOS

<table>
<thead>
<tr>
<th>Year</th>
<th>Description</th>
<th>Most-Likely Case</th>
<th>Worst-Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>Utah Lake Benefits</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td></td>
<td>Jordan River Benefits</td>
<td>$ 500,000</td>
<td>$ 500,000</td>
</tr>
<tr>
<td></td>
<td>Great Salt Lake Adverse Affects</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>$ 500,000</td>
<td>$ 500,000</td>
</tr>
<tr>
<td>1986</td>
<td>Utah Lake Benefits</td>
<td>$ 5,870,000</td>
<td>$16,930,000</td>
</tr>
<tr>
<td></td>
<td>Jordan River Benefits</td>
<td>$ 20,000</td>
<td>1,720,000</td>
</tr>
<tr>
<td></td>
<td>Great Salt Lake Adverse Affects</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>$ 5,890,000</td>
<td>$18,650,000</td>
</tr>
<tr>
<td>1987</td>
<td>Utah Lake Benefits</td>
<td>$ 4,840,000</td>
<td>$ 45,000</td>
</tr>
<tr>
<td></td>
<td>Jordan River Benefits</td>
<td>$ 30,000</td>
<td>Negligible</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>$ 4,870,000</td>
<td>$ 45,000</td>
</tr>
<tr>
<td>1988 and</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beyond</td>
<td>Total</td>
<td>$ 45,000</td>
<td>$ 45,000</td>
</tr>
</tbody>
</table>

---

\(a\) Based on 1,500-cfs outlet at Utah Lake and assuming inflow continues at 1984 level in 1985-87 and then returns to normal.

\(b\) Based on 1,500-cfs outlet at Utah Lake and assuming inflow equal to 1984 levels in 1985, increasing by 30 percent in 1986 and then returning to normal.

\(c\) Assumes program is not implemented in time to significantly affect lake levels in 1985.

\(d\) Represents benefits from reduced peak flow in Jordan River and repairs made to water control structures.

\(e\) Damage at 4,494.7 less damage at 4,491.6 (lake rises 2.3 feet above compromise with program): $6,180,000 - $310,000 = $5,870,000.

\(f\) Damage at 4,495.8 less damage at 4,494.1 (lake rises 4.8 feet above compromise with program): $20,800,000 - 3,870,000 = $16,930,000.

\(g\) Represents mitigated recreation losses resulting from reduced flow in Jordan River.

\(h\) Represents savings in flood-fighting costs and mitigated recreation losses resulting from reduced flow in Jordan River.

\(i\) Drawing down the level of Utah Lake would increase the level of Great Salt Lake by about 1-1/2 inches. The stage-damage curve for the Great Salt Lake and forecasts of the lake level under rainfall conditions similar to those assumed for Utah Lake indicate it is extremely unlikely the 1-1/2-inch increase will result in any significant additional damage.

\(j\) Damage for recurrence of flooding at 4,494.7 less damage at 4,491.6: $5,150,000 - $310,000 = $4,840,000.

\(k\) Represents average annual savings in pumping costs because of changes in outlet at Utah Lake.
followed by a return to normal, and 2) an inflow to Utah Lake approximately equal to 1984 levels in 1985, increasing by 30% in 1986 and then returning to normal. A summary of the flood prevention benefits by year for these two weather scenarios is presented in Table 2. Benefit-cost ratios for these two scenarios were computed assuming a 30-year useful life of the facilities and an 8% interest rate. The most cost-effective flood-control alternative was to enlarge the outlet structure and Jordan River channel capacity to allow approximately 1,500-cfs releases. Based on a cost of $10.5 million for this alternative, the most-likely case weather scenario had a B-C ratio of 1.0 compared to a ratio of 1.7 for the worst-case scenario.

References


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1984 "Floodling and Landslides in Utah: An Economic Impact Analysis." Salt Lake City: Graduate School of Business, University of Utah, and Utah Department of Community and Economic Development, Utah Office of Planning and Budget.


Salt Lake County and Utah County

Water Resources Council
EXPECTED ANNUAL DAMAGES
WITH AND WITHOUT LEVEES

Robert M. Watson
Wisconsin Department of Natural Resources

Introduction

Since the inception of the National Flood Insurance Program in 1968, the federal government has struggled to develop a clear policy with regard to levees. In the early 1970's, any levee with a crown elevation above the 100-year level was credited with providing 100-year protection. Then in February 1981, an "Interim Levee Policy" was issued from Federal Emergency Management Agency (FEMA). Many issues previously overlooked were addressed in the policy, especially the design height. The policy, still in force today, requires a minimum height three feet above the 100-year flood elevation. This "freeboard" requirement provides assurance that the degree of protection afforded by a levee system is at least 100-year. The policy also established criteria relative to ownership, inspection and evaluation, closure structures, mapping, design, and construction standards for new levees. If a levee meets all of the requirements, areas protected by the levee will be removed from 100 year floodplain designation. This in turn will remove floodplain zoning restrictions and the mandatory purchase of flood insurance. The policy has been applied on a case by case basis since 1981.

In October, 1982, the National Research Council of the National Academy of Sciences presented a report titled A Levee Policy for the National Flood Insurance Program to FEMA (NRC, 1982). Many issues were presented in the report, including structural criteria, inspection, operation, maintenance, warning, evacuation, mapping and design height. Within the introduction of the report six areas of concern are listed, as previously indicated by FEMA. Of the six, two relate directly to the focus of this paper. They are:

"4)...the degree of protection to be expected from a 100-year design levee is less than that obtained by elevating individual buildings to the 100-year flood elevation because of...greater depths of flooding experienced in unelevated structures upon levee overtopping or failure."
and

"5) Crediting a levee system with protection against the 100-year flood would, under present interim procedures, remove essentially all floodplain management requirements, lender notification requirements, and insurance purchase requirements within the levees area...." This could violate the spirit of the National Flood Insurance Act by encouraging development in areas subject to major flood damage.

The committee recommended, in spite of the initial recognition that levees do not offer "permanent" protection, that a 100-year design levee is sufficient to remove the requirements for elevating structures built behind a levee. The committee conversely recommended that a levee providing at least 500-year protection is sufficient to remove the requirement for mandatory purchase of flood insurance. If statements 4) and 5) above are accurate, then these standards should not be established until criteria is developed which accurately determine the effects of such a policy.

Both the Corps and FEMA currently evaluate risk in floodplains based on an annual assessment of potential damages. The Corps derives benefits (i.e., reduction in damages) based on a decrease in the frequency of flooding due to a proposed flood protection structure. FEMA derives actuarial insurance premiums based on the frequency of flooding in an area. However, neither approach evaluates the disparity of the residual risk behind a levee caused when floodplain management and/or mandatory purchase of flood insurance are removed.

Two questions will be addressed in this paper: 1) Does a 100-year design levee provide the same degree of protection as elevation of individual structures in compliance with current regulations? and 2) If the answer to question #1 is NO, what design level does?

Scope

A comparison of annual damage has been conducted for 1) a residential structure built in compliance with federal requirements and, 2) a similar structure located behind a levee built on grade. The methodology used is modeled after the Hydrologic Engineering Center (HEC) "Expected Annual Damage" (EAD) technique. This technique is being used since it appears to be the only method to make a valid comparison of risk behind a levee. It also relates directly to current policy within both the Corps (to evaluate the benefits of levees), and FEMA (to determine actuarial flood insurance rates). Recommendations will be made at the end of this paper to apply the results of the
comparison to develop criteria for the design height of new levees and the removal of floodplain management/flood insurance.

The comparisons of EAD contained in this paper are based on the following assumptions:

1) The levee will fail by overtopping (without breach failure).
2) The levee meets Corps design, construction, operation, and maintenance requirements with regard to structural stability.
3) The levee will provide protection only to the design flood, not to the freeboard elevation, to account for the uncertainties of hydrology and hydraulics.
4) Damages to structures are based only on inundation depth, not flowing water, where damage from velocity would occur.
5) There is no threat of flooding by interior drainage.

Admittedly, all of the above assumptions present a somewhat idealistic situation. For example, lack of maintenance will obviously decrease the level of protection as originally designed, and therefore increase a calculation of annual damages. Any serious attempt to utilize the EAD comparison will therefore need to consider these additional factors.

Expected Annual Damage Comparisons

The Expected Annual Damage, as Johnson (1985) explains in his paper, is computed from damage/frequency relationships which relate estimates of damage to expected frequency of occurrence. Elevation/damage relationships are developed for damageable property and elevation/frequency relationships are developed to define the flood hazard. The two relationships are combined to produce a relationship between damage and frequency. These elevation/frequency curves are commonly developed through the use of 1) a rating curve which relates water surface elevation to channel flow, and 2) the flow/frequency relationship which is derived from watershed characteristics. In the process of developing an elevation/damage curve, the first flood elevation of the structure is required. The second step is to relate the elevation of a specific flood frequency to the elevation of the structure. Figure 1 illustrates exactly how expected annual damage is calculated. The combination of the elevation/frequency curve and elevation/damage curve results in the combined curve (damage vs. frequency). The area defined under this curve is the expected annual damage for the structure (or structures).

As mentioned above, EAD comparisons have been derived for the following
Expected Annual Flood Damage Computation

FIGURE 1
two conditions: 1) new residential structure on fill, first flood at the 100-year elevation, no basement; and 2) new residential structure built on-grade, located behind a levee, with basement.

Figure 2 illustrates the difference in the type of construction between the two conditions. Note that condition #1 models the type of construction that would comply with federal requirements for a structure to be built in the floodplain. The "lowest flood" is at the 100-year elevation, neglecting the crawl space. In condition #2, no building restrictions apply because the floodplain designation has been removed from the area following the construction of the levee. Therefore, a basement is allowable under local building codes. (This may vary in different parts of the country where basements are not standard. In those cases, this EAD comparison will have to be adjusted.)

To address Question #1 (above) related to the "degree of protection" provided by the levee, the comparison for condition #2 will assume that the levee provides at least 100-year protection. To obtain a valid comparison of the two conditions, (#1 and #2), the following additional parameters have been established:

1) For condition #1, the structure sustains damage for all frequencies in excess of the 100-year flood occurrence, starting at the first flood level.

2) For condition #2, the structure sustains damage shortly after overtopping of the levee (i.e., 101-year flood). Therefore, damage is assumed to occur for all frequencies in excess of the design frequency of the 100-year flood occurrence.

3) EAD calculations for condition #2 were derived for a six-foot, three-foot, and one-foot depth of water at the 101-year flood, above the first flood elevation. This simulation indicates sustained damage starting at the 101-year flood occurrence (which corresponds to an elevation one foot below the first flood elevation). Damage at this level relates to structural damage in the basement.

4) For both conditions, FIA "stage/damage" curves (structural damage only) and "elevation/frequency" curves were used to derive EAD calculations (see Figure 3 and Table 1). Both sets of curves are based on empirical data derived by FIA. Site-specific data must be used to derive a "best" estimate of EAD. FIA data have been used in these calculations to derive a "generic" comparison, and so that the results can be applied directly to established policy within FEMA.
Expected Annual Damage Comparison

FIGURE 2

ASPECTS OF REDUCTION
Selected FIA Median Depth-Frequency Curves

FIGURE 3
1974 FIA Depth-Damage Data

<table>
<thead>
<tr>
<th>Depth (feet) above and below first floor</th>
<th>One-Story No Basement</th>
<th>One-Story With Basement</th>
</tr>
</thead>
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Note: Damage as percentage of structure or contents value.
EAD comparisons were also made for both conditions #1 and #2 for two different "Flood Hazard Factors" (FHF1 and FHF4) to reflect differing watershed conditions. The numerical subscript in FHF1, for instance, relates to the difference in feet between the 100-year flood elevation and the ten-year elevation. FHF1 simulates a river system with a wide flat floodplain, where there will be very little difference in elevation between flood frequencies (above the channel bank). FHF4, on the other hand, simulates a larger difference in elevation between flood frequencies, related to the river system where the overbank is steeper or where the river valley is relatively narrower. These two simulations should represent a large majority of river systems nationwide.

Table 2 shows the EAD calculations for all of the parameters indicated above. The results indicate that annual damages for condition #1 and condition #2 are equal only when the first floor for condition #2 is one foot above the 100-year elevation.

This indicates, based on the assumptions listed above, that a 100-year design levee does not provide the same "degree of protection" as current federal requirements for construction in floodplain areas.

<table>
<thead>
<tr>
<th>Condition #1</th>
<th>Condition #2 (100-year design levee)</th>
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<tr>
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</tr>
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<tr>
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<td>-1</td>
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<td>FHF4</td>
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<tr>
<td>EAD = 84</td>
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</tr>
<tr>
<td>-1</td>
<td>90</td>
</tr>
</tbody>
</table>

d: depth of flooding above first floor (101-year flood)
EAD: Expected Annual Damage in dollars, structure value equals $60,000.
To address Question #2 above related to the "optimum" design level, an iterative procedure was used to determine the design height required to provide the same degree of protection for condition #2. The results indicate that at the six-foot depth condition, a 500-year design is necessary. Obviously, since the EAD will decrease with a small depth of flooding (as shown in Table 2), the required design level for less than a six-foot depth condition will be less than a 500-year design. The results indicate, therefore, that in order to provide "equal protection" the required design level will vary, depending on local topography and frequency of flooding, ranging between the 100-year and the 500-year design for depths of flooding less than six feet.

Recommendations

Application of the EAD comparison must obviously be made only on a site specific basis, given the limitations of the empirical data used herein. However, the results point out the apparent inconsistency of the present Levee Policy within FEMA and the Corps design approach.

Annual damages could become increasingly higher as new construction occurs behind a certified levee (as compared to annual damages with floodplain management standards in place). This new construction in all likelihood will not be covered by flood insurance since there will be no requirement to purchase it. In addition, those that do purchase insurance will pay a premium that will not reflect the "annual damage" calculation. This could either be a financial burden on the NFIP or unfair to the policy holder, depending on how the EAD calculation compared with the subsidized rate. Based on the results of this study, the policy holder will be overcharged.

Implications of this comparison go beyond floodplain management. It would seem appropriate, for instance, for the Corps to determine the optimum "degree of protection" for proposed flood control structures in tandem with optimizing the cost-benefit ratio. This seem especially appropriate since the Corps obviously takes into account benefits derived on the assumption that floodplain management (i.e. fill requirements) will be removed. It seems inconsistent to include benefits which assume these construction requirements are removed, while neglecting that residual risk created by their removal.
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Natural Resources Council
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PART TWO

APPROACHES TO FLOOD HAZARD MITIGATION
A DISASTER THAT DOESN'T HAVE TO HAPPEN:
The East Baton Rouge Parish Flood of 2001
Rod E. Emmer
Coastal Environments, Inc.

In 1983, the Amite River Basin and East Baton Rouge Parish (County) suffered a record flood that caused damages of $171.7 million in the Basin, including $65.3 million in the Parish (USACE 1984). This was only the most recent event for the watershed which has experienced four major floods from 1972-1983. Floods are certainly not a new occurrence to the region, but the events are becoming more costly and as a result are causing a greater public cry for government action to reduce the problem. The personal hardships and monetary losses could have been avoided to a significant degree had state and local governments initiated and implemented a rationale flood damage reduction program during the past 20 years. Instead inaction and myopic planning for single purpose projects resulted in the present hazardous situation. It is the purpose of this paper to describe the problem and suggest a long-term solution that has been ignored by decision-makers.

Along with other sunbelt states, Louisiana grew rapidly during the sixties and seventies; this growth was particularly evident in East Baton Rouge Parish, the site of the state capital, the location of two major universities, and a center of petrochemical industries within the Mississippi River industrial corridor. In 1980, the population was 366,200, a 63% increase from 1960. Population projections (Maruggi and Fletes 1983) show that the Parish could grow to 551,100 by the year 2000, an increase of 66% over 1980. The earliest flood worthy of note was in 1907 when the population of the parish was approximately 33,000.

East Baton Rouge Parish is approximately 293,500 acres, 113,000 acres of which are within the 100-year flood zone (Federal Emergency Management Agency). The urban or built-up area grew from 24,500 acres in 1956 (Singleton 1972) to 81,400 acres in 1979 (USGS 1979). With pressures to convert more lands from agricultural uses, forests and open space, development extended more and more into floodprone areas, while at the same time compounding the problem by increasing runoff as a result of impervious surfaces, such as roads, roofs, and parking lots. The topography contributes to the problems through the low elevation and overall low relief of the Pleistocene terrace and Mississippi River valley. Streams are contained within well defined
channels most of the year but during flood the waters spread across valley floors. Most damage results when winter or spring fronts linger in the area and cause headwater flooding, i.e., high stages due to runoff from excessive precipitation over the drainage basin. To complicate matters, backwater flooding occurs along the lower reaches of tributaries when high water on the Amite River impedes runoff from secondary streams and causes impounded water to overflow onto adjacent areas. In 1983, the most devastating flood inundated 55,000 acres in the parish and damaged 1578 homes and 37 businesses (USACE 1984).

Flood damages are not attributable to a lack of planning. Beginning in 1946, land use plans were prepared for the parish. The first was by Harland, Bartholomew and Associates (1946) that described the city as complicating the natural flooding of the metropolitan area by providing inadequate facilities. The Bartholomew plan (1946) recognized that "the drainage problem is not a problem only of the Baton Rouge metropolitan area, it has certain regional aspects that must be given consideration before the problem can be solved." A more recent independent plan (Singleton 1972) suggested setting aside the floodplains for open space use and flood conveyance. In 1983, the East Baton Rouge Planning Commission Staff (1983) made a strong recommendation aimed directly at reducing future flood losses by stating: "Prevention of the development of residential subdivisions or multi-family residential complexes in areas subject to inundation should be a primary consideration in determining which vacant land should be earmarked for future residential use." However, elected and appointed decision-makers do not implement these recommendations and voters defeat tax proposals that would pay for drainage costs (Morning Advocate 1984a).

Greater damage is attributable to obstructions to flow, increased runoff from development, and encroachment into the more hazardous areas. Subdivision filings, elevations, and higher percentages of subdivisions in floodprone areas show the attraction to the more hazardous locations (Dudash 1984, East Baton Rouge Planning Commission Staff 1983). In addition, subdivisions originally built above flood levels now are victims because of upstream development that pours more water through them faster than existing drainage channels can handle.

Government suggests structural public works projects as the best alternative for reducing flood damages. Channelization of watercourses partially resulting from recommendations in the
Bartholomew plan, was initiated in 1957 by the state and parish (USACE 1974) and shifted the problem to the then less densely populated areas along the Amite River. In 1965, additional drainage and flood control projects were implemented. The U.S. Army Corps of Engineers (1979) studied a flood control plan for the Amite River Basin, but the benefit to cost ratio did not exceed one. Several dams, channelization, and diversion projects were studied by the State Department of Public Works but were not implemented because of opposition or the defeat of financing proposals.

In 1983 the Office of Public Works, Louisiana Department of Transportation and Development, undertook still another study and prepared a Preliminary Engineering Report on a Comite River Diversion Channel and an Engineering and Economic Feasibility Report for a dam and reservoir on the Amite River (Office of Public Works 1984a & 1984b). The Comite Channel diverts a portion of the Comite flood waters into the Mississippi River through a corridor north of the more densely populated floodplains of the City of Baton Rouge. The Office of Public Works estimates the cost to be between $62 million and $104 million, depending on capacity, location, and nature of channel, i.e., earthen or paved. The multi-purpose Amite River project, located north of East Baton Rouge Parish, is an earthen dam, 19,950 feet long and 80 feet high, creating a 15,000 acre permanent reservoir providing "flood control, recreation, a large supply of potable (drinking) water and hydroelectric power" (Office of Public Works 1984). Storage of floodwaters requires an additional 4000 acres. The $130 million project reduces water levels from an event similar to the 1983 flood by as much as 6.6 feet in some parts of East Baton Rouge Parish and may have reduced damages from $171 million to $35 million in the basin. For the first time benefit to cost ratio is above unity (USACE 1984).

These structural plans are proceeding with little or no study or evaluation of the primary and secondary beneficial and adverse impacts of the actions on the physical, biological, and cultural setting of the basin. Rather than early integration of these concerns into the planning process (National Environmental Policy Act of 1969, as amended), the environmental issues apparently are being included as an afterthought to satisfy Federal permitting requirements. Analysis of all issues and realistic alternatives in a full disclosure document may result in identification of better solutions for flood damage reduction that must either be integrated with the projects, result in modification of the proposed projects, or cause abandonment of it.
The plans and benefits attributed to the projects envisioned by engineers sound ominous because they very closely parallel the project and proclamations of safety and savings described by Platt (1982) for Jackson, Mississippi. Both study areas have similar flood characteristics; the floodplains are multi-jurisdictional with special flood districts; studies were conducted by U.S. Army Corps of Engineers; and both basins selected structural techniques for the solution to the flood problem. The 1973 USACE report "did not call into question Jackson's planning and zoning policies which allowed further encroachment upon floodplains" (Platt 1982). The Office of Public Works' Reports do not mention regulation or zoning of floodprone lands within the Amite River Basin and in particular in East Baton Rouge Parish where most of the existing and potential damage occurs. Short-sighted planning is unfortunate because the flood victims will pay for the agency's inadequate flood damage reduction planning as well as having to pay for the project.

A long-term solution to flooding in East Baton Rouge Parish and the Amite Basin is a comprehensive flood damage reduction plan for the Basin. Where feasible, structural techniques protect existing development; when necessary the government purchases property and relocates people; and throughout, zoning and regulation prevent the rampant filing of subdivisions and building of homes in the highest risk area. These issues and the mix of components in the basin need to be systematically evaluated and can be efficiently completed by modelling land use changes and benefits as well as costs. The first step is to delineate the floodway, which, in the case of this basin, includes the backwater areas. Simultaneously, zoning laws can be formulated for adoption and financing methods can be proposed and evaluated. The vehicle for this type of planning exists.

The Amite Basin Drainage and Water and Conservation District was formed in 1981 to propose long-term solutions for flood damage reduction. The Board, appointed by the governor, included at one time or another mayors, councilmen, police jurors, and other community leaders representing the six parishes in the Amite River Basin. Instead of having an active, innovative program which includes subcommittees to evaluate alternatives, investigation of approaches for generating revenue to implement a plan, and which involves more of the general public, the board has waited for directions from the state. One past Board President said he was disappointed that the state didn't come forward with funds and stronger directives for the Board (Morning Advocate 1982). The Board relies on the Office of Public Works and its single-minded
Emmer

approach to flood damage reduction for solutions. Only one or two on the Board has ever spoken of reducing damages; most only desire lowering water levels; but this does not automatically result in less damage in the long term. The Board needs to be revised if it is to take a lead in reducing flood damages.

However, changing leadership is only the first step. Implementation of a comprehensive approach will take education of the general public. Public and private attitude at this time may not allow for a comprehensive plan. An ordinance proposed in 1981 (Morning Advocate 1981) to severely limit construction in East Baton Rouge Parish floodplains was not implemented. One councilman is on record as stating the key to keeping development going in the fastest growing areas of the parish is cleaning drainage canals to make the floodplain smaller (Morning Advocate 1981). Other elected officials feel that the state or local governments cannot prevent people from building in floodplains (State Times 1983). Flood victims have strongly expressed a desire for the dam and diversion at public meetings and meetings sponsored by special interest groups such as Friends United for Darlington (FUND), a coalition of flood victims living in the lower end of the basin. Controversy has lead to the expected upstream-downstream conflict between those who demand protection and those whose lands are being taken (Morning Advocate 1984, State Times 1984). Opposed to the dam are landowners from the parishes of East Feliciana and St. Helena whose properties will be seized for the project. The Amite River Conservation League is an action oriented group of upstream residents who believe the burden of flood damage reduction should be shared with downstream floodplain occupants by including zoning for open space use of floodplains, floodproofing, and use of small structures strategically distributed throughout the watershed.

All of the factors are rapidly coming together in East Baton Rouge Parish for a devastating flood of unequalled dimensions. Populations pressures cause homes to be built in high risk areas; a structural plan, as proposed, provides the false sense of security necessary to encourage additional accelerated growth; heavy frontal precipitation occurs every three to four years; the government and the private sector systematically ignore floodplain management; and finally no comprehensive plans are being considered. Once all the pieces come into place, at about the same time the dam and diversion are completed in 1997, a flood of record will inundate East Baton Rouge Parish by the year 2001. Population projections forecast more than prosperity, they foretell of devastation for those many who buy and build in the floodplain,
thinking the dam and diversion have solved the spring problems. It is a disaster that can be prevented if parish decision-makers implement some of the recommendations of their professional staff and work with others in the Basin to prepare and implement a comprehensive flood damage reduction program that will reduce the long-term impacts and the short-term problems.

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RELOCATION: A FLOODPLAIN MANAGEMENT ALTERNATIVE

Byrt Wammack
U.S. Army Corps of Engineers,
Los Angeles District

Introduction

As a floodplain management alternative, relocation provides unique opportunities to maximize local, regional, and national benefits from flood control projects. This paper illustrates how these benefits can be realized through cooperative master planning efforts. Relocation is consistent with federal policy and can satisfy the federal objective to lessen flood losses. It also provides nonfederal interests unique opportunities to get more for their dollar. In light of proposed cost-sharing reforms and recent policies, this should be even more desirable. A brief review of a completed relocation project and a description of an ongoing relocation study illustrate how cooperative master planning can lead toward more efficient use of resources and maximization of local, regional, and national benefits.

Economic and Policy Framework

In the Flood Control Act of 1938, Congress authorized the Corps of Engineers to consider relocation as an alternative to structural measures. But since 1974, Public Law 93-251 requires federal planners to consider relocation or other nonstructural alternatives in the survey, planning, or design of any federal flood protection project.

For evaluation of flood protection alternatives, economic efficiency has remained the primary federal objective, although secondary objectives such as environmental quality, regional economic development, and social welfare have also been included. Currently, there is only one federal objective for water and related land resources planning—"to contribute to national economic development consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements." Contributions to national economic development (NED benefits) are defined as "increases in the net value of the national output of goods and services" (P&G 2.0.0, 1983).
The other criteria—environmental quality, social welfare, and other social effects—may still be included, but are not required. Although RED is no longer a federal objective, it cannot be completely separated from the NED objective. RED benefits include NED benefits realized at the regional scale, income transfers, and employment benefits (P&G. 1.7.1, 1983). Thus, RED should be seriously considered at the federal scale and should be the primary nonfederal objective.

External Benefits and the Nonfederal Share

Nonfederal interests already share in the costs of flood control projects, but in efforts to improve efficiency and equity, cost-sharing reforms are being proposed. These are reflected in the Reagan administration's water project financing and cost-sharing policy which states in part that, "project beneficiaries, not necessarily governmental entities, should ultimately bear a substantial part of the cost of all project development" (Reagan, 1984).

According to proponents of this policy, cost-sharing "would 1) reduce the bias toward projects which are larger than is optimally efficient, or not efficient at all, 2) reduce the bias toward nonreimbursable purposes, and 3) reduce the proportion of the project cost paid by the general taxpayer" (Waelti, 1985). More importantly, however, such policies should provide additional incentive for nonfederal interests to get more from their investments. This means maximization of RED as well as NED benefits; and one source of RED benefits is from external project benefits.

In addition to flood control, projects have other impacts. In some projects, such external effects will be negligible, but in others they can be substantial. If these external effects are beneficial, they can significantly increase the total benefits of a project. Thus, maximization of a project's external benefits, in addition to its direct benefits, will provide the optimal return on both the federal and nonfederal investment. This can be achieved through cooperative master planning at the federal and nonfederal levels.

Relocation

Relocation provides unique opportunities to maximize the return from both the federal and nonfederal investment. Not only is it possible to eliminate completely future flood-related costs, but opportunities also exist to 1) replace declining flood-prone neighborhoods with improved flood-free neighborhoods, and 2) to conduct the relocation process in the broader context of community and regional economic development.
Relocation is not always the best alternative. However, if a community has a severe flood problem, if the depth of inundation makes floodproofing impractical, if structural measures are expensive, and if the community can benefit from economic development or redevelopment, then relocation may be the best alternative.

Soldiers Grove, Wisconsin--A Completed Relocation Project

Soldiers Grove is currently receiving attention as America's only solar village, yet only a few years ago it was merely another village in the floodplain. Situated along the banks of the Kickapoo River, Soldiers Grove was flooded in 1907, 1912, 1917, 1935, and 1951. A levee was proposed, but the cost of maintenance would have been prohibitive and would have done little to solve the other problems—"the outmigration of young people to urban areas, the severe blight in the downtown, the feeling that Soldiers Grove was slowly dying" (Becker, 1980). In 1978 another flood hit, but by that time the community was convinced that relocation was the answer, and a concerted effort began. Four years later, in 1983, the work was nearly done.

"The village gained enterprises it didn't have before. They include a dental clinic, restaurant, nursing home and pharmacy." Total employment increased from 95 to 155. In 1980, "Soldiers Grove's population was up for the first time in years, from 514 in 1970 to 622 in 1980". "Its tax base grew by nearly 2 million dollars" (U.S. News & World Report, 1985). In short, relocation of Soldiers Grove did more than eliminate the costs of floodplain occupancy. A new comprehensive community plan which integrates relocation, energy efficiency, and city ordinances provides the community with a more stable economic future, and thus benefits the regional and national economies.

Clifton, Arizona--Flood Control and Redevelopment

The Los Angeles District Corps of Engineers is currently conducting a study of flood control measures for the town of Clifton, Arizona. A major feature of the plan under consideration is relocation of over 100 families and businesses to a flood-free site. Historically, Clifton has been dependent on the copper industry. Because of a downswing in the copper market, a recent strike and a severe flood, it is necessary to integrate the flood control plan into Clifton's plans for redevelopment.

Clifton was founded in 1873 in a deep narrow canyon on the banks of the San Francisco River, after copper was discovered nearby. Lands outside of the floodplain were either public or in the ownership of the mines. Due to the
lack of land for development, economic growth and diversification were limited and the community remained dependent on the mines. Frequent floods posed a continual threat to the community. Velocities were high and depths great. Floodwalls provided limited protection and a flood warning system was installed for safety. Other solutions such as dams, levees, and channels were considered by the Corps of Engineers and others, but because of excessive costs or impracticability, nothing was constructed.

In April of 1982 the mine was shut down and did not open again until October, with a reduced workforce. In July of 1983, the union struck rather than accepting further concessions (The Register, 1983). Three months later on October 1, 1983, the flood-of-record hit, inundating over 300 homes and businesses. Now, a year and a half after the flood, the Town of Clifton is still trying to pull itself together from the flood, the strike, and years of dependence on "the company."

Planning efforts immediately following the flood concentrated on flood recovery and permanent solutions to the flood problem. Because of the numerous federal, state, and local agencies involved in these efforts, the need for cooperative planning was apparent. To coordinate these activities, the Governor of Arizona formed a special task force to provide a forum for agencies who could assist in flood recovery. Another group, the Clifton Flood Recovery Working Group, was formed to work with the Corps study team. The Corps study proceeded from reconnaissance to the feasibility phase, largely as a result of the efforts of this nine-agency working group.

Even before others got involved, the Town of Clifton saw a need to plan for redevelopment of their community towards a future free of flooding and independent of the mine. Since these two goals are so interrelated, master planning became the focus of the cooperative planning efforts. Two committees were formed by town council resolution. The Technical Advisory Committee, which includes representatives of federal, state, and local agencies and the Chamber of Commerce, was formed to develop a comprehensive plan for the community. The Citizen's Relocation Committee was formed to provide an interface between the community residents, the Technical Advisory Committee, and the Planning and Zoning Board. The Citizen's Committee is also working to gain Congressional support for the flood control project. The ultimate goals of the committees are 1) business retention, 2) economic growth and diversification, and 3) implementation of the structural/nonstructural flood control plan.
Because of the downswing in the copper market, the strike, and the flood, the survival of Clifton is dependent on economic redevelopment. Redevelopment is a process, and relocation could impinge on that process. Yet, without flood control, redevelopment would not be possible. This potential for problems simply provided the opportunity to rally additional expertise to aid in master planning the community. If redevelopment is successful, it will be the result of cooperative master planning.

If the future Clifton is a flood-free community that is in harmony with the environment and meets the social needs of its people, if it is a community with economic diversity that contributes to the growth of the region, the state, and the nation, then the federal and nonfederal objectives will be met and the project will provide the maximum return for the investment.

References


RELOCATION OF A LARGE, SLAB ON-GRADE HOUSE FROM A FLOODPLAIN

Edwin C. Endacott
US Army Corps of Engineers

Introduction

Haikey Creek is one of several creeks that flow outward from the city of Tulsa, Oklahoma, toward the Arkansas River. The 37-square-mile Haikey Creek watershed is funnel shaped. It lies entirely within southern Tulsa County and the rapidly developing southeast quadrant of the Tulsa metropolitan area.

The area receives an average of 37 inches of rain a year and is prone to violent thunderstorms that often cause serious flooding problems along creeks and rivers. Before the 1960's, the Haikey Creek basin was largely devoted to agricultural uses, and frequent floods curtailed truck farming on the rich bottom lands. The Soil Conservation Service recorded 35 major floods and 80 minor ones along Haikey Creek between 1940 and 1960, with damages almost exclusively confined to agricultural activities.

Today, the watershed is about 25% developed with mixed residential and commercial. Development occurs mostly throughout the northern part of the watershed that encompasses the city limits of Tulsa and its suburb, Broken Arrow. Rapidly spreading urbanization is spilling over these uplands, but much of the watershed remains unincorporated and undeveloped, dotted with farm dwellings and scattered developments. A burgeoning suburb, Bixby, extends into the southwestern portion of the watershed.

In the lower two miles of the watershed, the creek skirts about 50 flood prone structures, mostly built during the 1970's and priced to attract upper-middle-income families. The rural isolation, tall trees, and lush vegetation attracted development in the years before flood plain management was extended to this and other unincorporated areas of Tulsa County. After serious flooding in 1974 and 1976, officials of Tulsa County requested that the US Army Corps of Engineers investigate the possibility of a local flood protection project on the lower reach of the creek. Subsequently, the lower area became the site for the US Army Corps of Engineers flood control project described in this report. Some of the owners of the homes in this
area have received flood insurance payments that exceed the homes' values.

Work began in 1982 on the Corps project, which includes construction of a levee around a subdivision and acquisition/clearance of some scattered upstream structures. One of the homes acquired was a large two-story house that the homeowner elected to move to a new floodfree site.

Although moving structures is fairly common in the Tulsa area, few large, two-story houses built on a concrete slab had been relocated. The owner agreed to allow the Tulsa District Corps of Engineers to document the process in this report, in the hope that it might help others considering such a move.

**Flooding Problem**

In early 1972, Ms. Nancy Kincaid built what she calls her "dream house" in rural Tulsa County. The two-story house contained 3,200 square feet with a rock and frame exterior, two large porches, and a native rock fireplace. It was built on 13 wooded and grassland acres, providing pastureland for the horses and sloping gently down toward a wooded creek about 600 feet behind the house.

The Kincaid house was built on an old, normally dry oxbow of Haikey Creek, near the bottom of the funnel-shaped watershed now being rapidly covered by suburban sprawl. Based on a September 1979 flood insurance study performed for the Tulsa County area, an estimated 2 feet of water, flowing as fast as 4 feet per second, could enter the house in a 100-year flood; flooding in the yard would be about 3.7 feet deep. The 100-year flood is a magnitude of flood flow that has a 1% chance of occurring in any given year. With future upstream development, the threat of flooding would increase.

**June 1974 Flood**

On the night of June 8, 1974, a trio of tornadoes and violent thunderstorms hit the Tulsa area, inflicting widespread damage that totaled nearly $50 million.

It was far into the night before the flood waters made their way down the meandering Haikey Creek to the bottom lands, where the water washed away an upstream levee and routed neighbors from their homes. "A family that lived near me escaped by walking out with three children on their shoulders..."
through waist-deep-water and they discovered later they had just missed some
downed power lines," Ms. Kincaid remembers.

Downstream in the Hickory Hills subdivision, about 40 homes were
flooded, including one where a family of 10 cut a hole through the roof to
escape water that rose as high as 6 feet in their house. In all, the flood
casted about $1 million in damages in the Haikey Creek project area. The
return frequency for the June flood was estimated as that of a 10 to 15 year
storm.

For Ms. Kincaid, the flood provided tangible proof of the flood
predictions, but the interior of her home received no damage. "The water
came within 2 inches of coming in the door, but none got inside the house," she says.

In the ensuing years, Tulsa County and the cities of Tulsa, Broken
Arrow, and Bixby -- which all share jurisdiction within the watershed --
adopted regulations on flood plain development to comply with the Federal
flood insurance program. In the mid 1970's, the Corps began planning a
local flood protection project under the authority of Section 205 of the
Flood Control Act of 1948, as amended.

**May 1976 Flood**

The second major flood hit on May 30, 1976. Again, the storm inflicted
widespread damage throughout the metropolitan area. Total damages were
estimated at more than $34 million, of which about $650,000 was in the
Haikey project area. Flood stages in the Hickory Hills area were 1-1/2 to 2
feet lower than the 1974 flood. Three persons drowned in the 1976 flood
within the city of Tulsa.

Once again on Haikey Creek the water moved more slowly down the largely
unmodified channel, so that the peak occurred in the early morning darkness.

"After it became clear that we were probably in for another flood, I
made what emergency preparations I could and waited -- for a long time," Ms. Kincaid remembers.

"The water rose very slowly until it surrounded the house. It rose into
the garage, which is lower than the rest of the house."

At about 3 a.m., water was 3 inches from her doorway. The level hovered
there for several hours, then almost imperceptibly began to recede. Once
again, no water had entered; the house was safe.
Corps Project

In April 1975, the Tulsa County Commission requested that the Corps investigate the flood problem along Haikey Creek under the authority of Section 205 of the 1948 Flood Control Act, as amended. The Corps received authorization to begin detailed studies in September 1975.

The 1976 flood sparked renewed interest in the Corps' Haikey Creek project, and planning meetings were well attended in the late 1970's when alternative flood control methods were debated. Some local officials and citizens wanted to channelize the creek to the Arkansas River; others favored a levee or upstream reservoirs; and still others wanted to move as many structures as possible out of the flood plain.

Forty-seven residences, three mobile homes, and three greenhouse complexes had been built within the standard project flood plain in the project area. The standard project flood results from the most severe storm expected in the watershed. Most of the houses lie within the Hickory Hills subdivision, about one-half mile upstream from Haikey Creek's confluence with the Arkansas River. Most of the other structures are scattered upstream of the subdivision.

The recommended plan is a combination plan combining a traditional structural solution with a nonstructural plan. The plan required construction of a levee and the removal or elevation of some flood plain structures. Benefits from the plan would exceed the costs by 2.5 to 1.

The structural part of the plan calls for a 5,700-foot levee to be built around the relatively dense development in Hickory Hills, tying into a hill that rises west of the subdivision.

In the upstream project area, which included the Kincaid house, development was more scattered, and other solutions were required. The Corps estimated that the levee, which would restrict flows downstream, could raise the level of a 100-year flood by as much as 0.5 foot in the upstream area for about one-half mile. Clearly, the government would have to take some action to offset that induced flooding in the upstream area. But levee or channel works were not economically justified in the upstream area.

Among options posed to upstream owners were floodproofing or building ring levees around their structures. As the Corps plan was being finalized, most of the inhabitants of the upstream area said they favored evacuation --
that is, total removal of their homes -- over floodproofing. They rejected floodproofing plans that they said could make their homes isolated "islands" during major floods. The Corps determined that the depths and velocities of water made floodproofing a questionable option for most upstream residents. For these reasons, the approved plan for the upstream area includes acquiring and removing most structures. Owners of one mobile home and one farmhouse preferred floodproofing, and the approved plan gave them the option to raise their structures in place.

In the plan implementation, Tulsa County was to be responsible for acquiring the lands, easements, and rights-of-way. The county was also to pay 20% of the cost of the nonstructural portion of the project -- the acquisition/clearance of upstream structures. The county portion was approximately $820,000 of the total $3.3 million project.

The Corps' Haikey Creek Local Flood Protection Project was approved in October 1981.

Moving The House

Acquisition

One of the homes to be acquired as a part of the Haikey Creek Local Flood Protection Project was the large two-story house owned by Ms. Kincaid. She decided to relocate the house, if it was feasible, rather than allowing it to be demolished on the site.

Properties needed for the Corps project were acquired by the local sponsor, the Tulsa County Board of Commissioners, with Corps approval. The county in turn contracted with a local agency with long experience in property acquisition, the Tulsa Urban Renewal Authority, to conduct the actual acquisitions. This arrangement resulted in extensive negotiations for Ms. Kincaid, because she and the staffs of three agencies had to reach consensus. Negotiations lasted several weeks, but agreement ultimately was reached in mid-October 1982. The price was based on fair market value, as determined by appraisers.

From the sale proceeds, Ms. Kincaid purchased back the structure for its estimated salvage value. The salvage value is the amount the government estimates as the value of the improvement for off-site removal.
Determining Feasibility

Before many firm decisions could be made, Ms. Kincaid had to determine the technical, economic, and legal feasibility of moving the structure. This step involved making a number of decisions, at least tentatively, including selecting a new site and a house mover.

A new site had been purchased before the decision was made to move the existing house. The purchase included 10 acres on a hill about 15 miles west and north of the Haikey Creek site. The new site is within the city of Tulsa but in a suburban fringe area that is still largely rural.

To select a mover, she queried government officials for the names of persons who had moved structures successfully within the Tulsa area. She interviewed those individuals and their movers. Many of the movers declined to bid because of the size of the house and its slab construction.

She selected a Tulsa-area mover, Mr. Charlie Frunk, after inspecting previous structures he had moved, obtaining his bid, and receiving his assurances that her home could be moved successfully.

"You learn a lot in this interviewing process about moving houses," Ms. Kincaid says, "because you really have to investigate each step of the process to evaluate the movers and their bids." She also obtained bids from contractors for plumbing and electrical work. For some people, this step might be simplified by obtaining a general contractor; Ms. Kincaid served as her own general contractor. Again, obtaining these bids involved a learning process about the steps involved in the move.

"The contractors' bids are really only estimates, because the scope of their work may change after the move, in ways you can't predict," Ms. Kincaid says. "For example, we lost some heating ductwork during the move that we hadn't counted on; the contractors' advance bids couldn't have taken that into account."

The next step was to assemble all the bids and estimate the price of the move. Ms. Kincaid checked with builders and government officials to estimate what she would have to pay for a comparable new house. She compared the costs of new construction, estimated at $40-$50 a square foot, against the estimated moving costs and determined that moving her structure was economically feasible.
Furnishings were moved back into the house, and Ms. Kincaid resumed occupancy in April of 1983. In all, the move and renovation work took about 6 months.

The tables below summarize total costs to the Government in conjunction with the Hailey Creek project and the costs incurred by the homeowner during the move.

### GOVERNMENT COST
ACQUIRING AND RELOCATING HOUSE

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market Value of House</td>
<td>$100,000</td>
</tr>
<tr>
<td>Salvage Value</td>
<td>-5,000</td>
</tr>
<tr>
<td>Net Payment for House</td>
<td>$95,000</td>
</tr>
<tr>
<td>Relocation assistance and interest differential</td>
<td>15,000</td>
</tr>
<tr>
<td><strong>TOTAL PAYMENT TO OWNER</strong></td>
<td>$110,000</td>
</tr>
</tbody>
</table>

### COST OF MOVING AND REBUILDING HOME

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>House mover</td>
<td>$15,000</td>
</tr>
<tr>
<td>Carpentry and materials</td>
<td>22,000</td>
</tr>
<tr>
<td>Air conditioning and heating</td>
<td>6,100</td>
</tr>
<tr>
<td>Foundation and slab</td>
<td>5,000</td>
</tr>
<tr>
<td>Masonry</td>
<td>4,900</td>
</tr>
<tr>
<td>Plumbing</td>
<td>3,700</td>
</tr>
<tr>
<td>Floor coverings</td>
<td>3,300</td>
</tr>
<tr>
<td>Electrical Work</td>
<td>1,600</td>
</tr>
<tr>
<td>Septic System</td>
<td>1,600</td>
</tr>
<tr>
<td>Painting</td>
<td>1,300</td>
</tr>
<tr>
<td>Sheetrocking</td>
<td>1,100</td>
</tr>
<tr>
<td>Insulation</td>
<td>1,100</td>
</tr>
<tr>
<td>Driveway (gravel) and Sidewalk (concrete)</td>
<td>500</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>900</td>
</tr>
<tr>
<td><strong>TOTAL COST</strong></td>
<td>$68,100</td>
</tr>
</tbody>
</table>

*NOTE: Data does not include costs for land, moving and storing furniture, or general contracting and other work that the owner performed herself.*
SECTION 406 HAZARD MITIGATION PLANNING:
CHANGES IN THE FEDERAL APPROACH

Larry Zensinger, Chief
Hazard Mitigation Branch, FEMA/Washington

Clancy Philipsborn
Hazard Mitigation Specialist, FEMA/Denver

Section 406 of Public Law 93-288 (The Disaster Relief Act Amendments of 1974) requires that Federal disaster assistance be conditioned upon appropriate actions taken by recipients of the assistance (for the most part State and local governments), to "mitigate" hazards and reduce the potential for future occurrences of disasters. These mitigation actions can include such things as building standards and land use and construction practices. During the past ten years, this section of the law has been applied with varying degrees of success. This paper will attempt to identify some initiatives the Federal Emergency Management Agency (FEMA) will be proposing to improve the consistency with which this section is applied, and will describe some recent experiences in field testing some new concepts for administration of Section 406. The authors specifically chose these ASFPM annual meetings for presentation of this material. Many of the problems that are identified, and FEMA's new approaches designed to mitigate them, are the result of direct input from ASFPM members. Thus, this forum is an appropriate means of communicating FEMA's responsiveness to the ASFPM's concerns.

Following enactment of PL 93-288, the Federal Disaster Assistance Administration (FDAA), then part of the Department of Housing and Urban Development, assumed responsibility for developing regulations implementing the new provisions of the Federal Disaster Act (The Act) including Section 406. Section 406 was assigned a relatively low priority in this process, however, and it was not until November 8, 1979, that regulations were published (at 44 CFR Part 205, Subpart M) to implement Section 406 of the Act. These regulations focused primarily on defining responsibilities and concepts and establishing procedures for FEMA and intergovernmental coordination. While this definitional and procedural approach was probably necessary in introducing the concept of post disaster hazard evaluation and mitigation, experience in working with the present format, and structural changes such as the development of the Integrated Emergency Management System, have revealed shortcomings in the present program approach and regulations.

Three problems in the current approach which FEMA recently has begun to address include lack of guidance on 406 plan scope and content, not viewing State hazard mitigation planning as an evolving and cumulative process, and not integrating 406 mitigation requirements into the comprehensive emergency management program of the State. By not providing guidance on Section 406 plan scope and content, FEMA has made it difficult, if not impossible, to condition disaster assistance on the implementation of appropriate mitigation measures by grantees. New Subpart M regulations, scheduled to be proposed some time during Fiscal Year 1985, will rectify this. By not viewing Section 406 planning as an evolutionary or cumulative process, FEMA has probably caused many States a great deal of frustration by not giving any credit for past accomplishments. Under the scant
Section 406 plan guidance currently in effect, all that States are technically required to do is a hazard mitigation plan for each disaster, regardless of their history of previous Section 406 or non-disaster related mitigation planning. The new regulations mentioned above will encourage States to establish ongoing state-wide hazard mitigation strategies and programs requiring, where these exist, only an updating and review of mitigation policies following a disaster, rather than drafting of a "plan." Finally, although mitigation has been included as one of the four phases of comprehensive emergency management (along with preparedness, response and recovery), it has not been integrated well by FEMA into the programs which support State emergency management planning. The creation of the IEMS, however, which starts with hazard identification and capability assessment, provides an ideal format for the Section 406 "hazard evaluation" and assessment of current State mitigation programs and capabilities. This will allow emergency planning assistance provided to States to be used, in many instances, to accomplish mitigation objectives.

Even though these concepts have not been formally established through the promulgation of regulations as yet, recent examples demonstrate how FEMA has begun to move in this direction. While these examples are from FEMA Region VIII, it should be noted that these efforts have their roots in the strategies of Alan William's work in the State of Connecticut, and the fundamental framework of IEMS. Mr. Williams has successfully demonstrated the importance and effectiveness of the involvement of all State agencies and particularly the Office of the Governor, in orchestrating a comprehensive State-wide hazard mitigation program. The IEMS format of hazard identification, capability assessment, multi-year development planning (HICA/MYDP) and implementation readily lends itself to the 406 process, while additionally providing FEMA the opportunity to practice what we preach; integrated emergency management.

Since last August, when many of us participated in the Emergency Management Institute's prototype course for State 406 hazard mitigation planning, Region VIII has developed State-wide multi-hazard 406 plans in South Dakota, Colorado, and Utah. Each planning effort was similar in that their framework, objectives, and methods were based on the IEMS and Connecticut examples. Each plan follows the HICA/MYDP format, and each plan thoroughly examined the existing authorities of appropriate State agencies as a means of accomplishing the capability assessment.

However, each planning effort differed due to initial information available, and differing levels of political acceptance and support. In South Dakota, this was the State's initial 406 plan, and it was partially based on recommendations of the Interagency Hazard Mitigation Team (IHMT). In Colorado, there was an existing 406 plan, but no IHMT was activated for this particular disaster. In Utah, there was not only an existing plan, but also an IHMT that offered suggestions for the new plan.

Most importantly, each planning process specifically addressed the three previously identified problems. Increased, organized, and goal-oriented guidance was provided. Previous mitigation efforts were recognized and expanded upon, rather then being ignored or duplicated. Initiatives were taken in order to create an avenue by which 406 implementation would be integrated into the States' emergency management programs.
In each of the three planning efforts mentioned, the Federal and State Hazard Mitigation Coordinators approached appropriate personnel within State agencies and local governments to explain the purpose and implications of the 406 requirement as well as each entity's responsibilities. FEMA hazard mitigation staff remained on-site in each instance in order to initiate State hazard mitigation task forces, identify potential areas of opportunity, develop a 406 outline, suggest recommendations, and to provide through coordination, the technical assistance and available resources of the other Federal agencies. In South Dakota, FEMA coordinated and paid travel expenses for representatives from six Federal agencies to travel to the State capitol and provide the State Mitigation Task Force with the requested technical assistance. These representatives also had served on the IHMT, and were therefore familiar with the situation. This group became the Federal-State planning team that developed and reviewed the State plan. In Colorado, a similar Federal-State planning team was developed. Since there was no IHMT for this disaster, the Federal representatives were from the local offices, in order to limit expenses. Many, however, had served on the IHMT and Federal-State Planning Team following the 1982 Lawn Lake/Estes Park disaster. In Utah, the same assistance was offered but declined by the State. 406 guidance now included procedures for format, content, implementation, monitoring, and enforcement.

The Colorado and Utah 406 efforts clearly demonstrate how past mitigation efforts are no longer ignored or duplicated. From the day of the Presidential declarations, this was explicit as the "standard" paragraph in the FEMA-State agreement which requires the 406 Plan was modified from,

The State agrees to prepare and submit...a hazard mitigation plan or plans for the FEMA designated areas...

(FEMA-State Agreement, FEMA-665-DR-CO, 07/26/82)
(FEMA-State Agreement, FEMA-680-DR-UT, 05/04/83)

to,

The State shall review the status of implementation measures from the current State 406 hazard mitigation plan in the light of the recent flooding, and modify or update such plan as appropriate to address new or additional hazard mitigation needs or issues.

(FEMA-State Agreement, FEMA-719-DR-CO, 07/27/84)
(FEMA-State Agreement, FEMA-720-DR-UT, 08/23/84)

This created the precedent of mitigation program reviews (MPR). The States' original 406 planning efforts strived to develop State hazard mitigation programs through establishing an increased priority for hazard vulnerability and loss reduction within existing authorities. Subsequent disasters then allow for an MPR rather than plan duplication. The intent of MPR's is to recognize and build upon past efforts; to analyze what initiatives did and did not work; to develop new or improved ideas; and to identify those recommendations that may well have reduced the current impact had they been implemented. (This is not entirely new. Illinois should be noted for their annual review of their 406 plan.) This type of program review then allows a plan to be updated not only in future disaster situations, but also on an annual basis as States fulfill their HICA/MYDP requirements for IEMS. Conversely, a disaster declaration could provide the opportunity to update a State's HICA at the county level where that
work had not yet been completed.

Finally, as a means of addressing the continual and critical problem of little or no funding for mitigation activities, several examples exist of efforts to integrate 406 planning efforts into States' emergency management programs. Following the Connecticut example of funding specific 406 recommendations through FEMA's CCA mechanism using SAP supplemental funds, FEMA Region VIII has requested State Hazard Mitigation Coordinators, through State Emergency Services Directors, to identify and include in their annual CCA negotiations, 406 tasks that can be funded and implemented through use of existing programs. FEMA provides States with funds through a variety of disaster preparedness and emergency management grants that can be applied to mitigation initiatives. As we work with States to establish mitigation as a priority, we are doing the same within FEMA. Further, as an evaluative criteria established for Hazard Mitigation Assistance Grants, (a new source of Regional funds to support mitigation activities) CCA proposals that indicate a State's willingness to apply these other program dollars to 406 items will be favored.

In conclusion, FEMA, both Nationally and Regionally, feels responsive towards the identified weaknesses and needs of State 406 planning efforts. We are attempting new, aggressive strategies to address problems as they arise. While it should not be expected that each new methodology prove successful, it can be anticipated that each will further our knowledge of this evolving process, and serve to improve our capability to decrease our nations vulnerability to our increasing hazards.
THE ROLE OF INSURANCE ASSOCIATIONS IN DEVELOPING
COMMUNITY FLOODPLAIN MANAGEMENT PROGRAMS

Robert Ross, Jr.
Florida Association of Insurance Agents

Insurance Associations for years have played an important role in providing training and education on insurance programs to the general public/consumer. The National Flood Insurance Program is no exception. Mr. Robert Ross, Jr., Director of Education for the Florida Association of Insurance Agents has been actively involved with the NFIP in Florida since its inception in 1968. In the following question and answer format, Mr. Ross will provide an insight into the role of Insurance Associations and the agent/producer in community flood plain management programs.

Q In general terms, what is the function of Insurance Associations in the insurance industry?

A The function of the Florida Association of Insurance Agents as a trade association involves a myriad of activities: legislative relations, marketing, agency management, insurance company/insurance agency relations for the consumer, and education.

Q Specifically, what role does the Florida Association of Insurance Agents (FAIA) play in the implementation of the NFIP in Florida? (i.e., training, education....)

A In the implementation of the NFIP in Florida, FAIA develops educational programs for its agent members, puts on schools in many cities throughout the state, provides technical expertise in policy interpretation and rating, and directly involves itself in efforts to make the processing of flood insurance more efficient, and the agent's role more productive.

Q What areas of the NFIP do agents get involved in other than policy writing and processing?

a) Do Agents get involved with the floodplain management regulations?

b) Do Agents have the capability to get involved in these areas?

c) Are Agents interested in these areas?

d) Is their involvement with the insured or the local official or both?
e) If the involvement is with local officials, how is this relationship initiated?

A In other than policy writing and processing, insurance agents are involved in the following other NFIP areas:

a) The clients of insurance agents call on them for interpretation of flood plain management regulations. When a building is built in violation of these regulations and no variances issued, the agent is often thrust into a battle between the community and the client because of the difficulty in obtaining a flood policy, and then the subsequent high premium involved.

b) It is difficult to say whether the agent has the capability to get involved in these areas. Some do. Some don't. Most, because they feel they have a responsibility to the client, become involved and try to learn as much about the flood plain management regulations as they possibly can. They often are the only ones who are willing to go that extra step.

c) As a result of their client involvement, agents are interested in these areas.

d) Their involvement is with the insured and the local official in most cases. Actually, the agent becomes a traffic cop between the insured (client), community officials, lenders, engineers, and any others involved. The agent ends up having to try to inform each of the parties where their responsibility lies and what might be expected of them.

e) The involvement with local officials is initiated by the agent at the request of the client, in most cases. We find that community officials don't seem to understand the tie-in between flood plain management and insurance. The fact that a community official is responsible for the estimated BFE (in unnumbered A Zones) tends to marry the agent to that community official. In many other ways, the community official can be helpful, but very often he has not been sufficiently informed of the role he might play by his superiors and by such agencies as FEMA and ASFPM.

Q Specifically speaking for the FAIA, what problems (if any) do you see that hinder the effectiveness of the NFIP in reducing future flood damages in Florida?
The primary problem that hinders the effectiveness of the NFIP in reducing future flood damages in Florida is lack of communication. Areas of responsibility, as mentioned above, should be more specifically defined.

What suggestions can the FAIA make which will improve the effectiveness and the efficiency of the NFIP, not only in Florida but across the nation as well?

To improve the effectiveness and efficiency of the NFIP, we would suggest:

a) Better communication.

b) Simplification in all respects; i.e., flood plain management insurance writing, manual preparation, written communications, verbal communications training, et al.
GALVESTON BEFORE AND AFTER ALICIA:
HOW CAN THE INSURANCE AGENT ASSIST IN THE
DEVELOPMENT OF HIGH-RISK AREAS

Fred E. Madsen
United Services Automobile Association (USAA)

USAA is the leading producer of flood insurance policies, under the NFIP, writing in all 50 states. Mr. Madsen, Director of Property Insurance Plans has been a key figure in the development and growth of the NFIP since its beginning in 1968. Hurricane Alicia, in August 1983, wreaked havoc with the Texas coast, especially the Galveston area. USAA, a prime insurer in that area, was actively involved in the redevelopment of the devastated coastline. Mr. Madsen, in the following question and answer format, will provide some insight into the role of the Agent/Producer in the development and redevelopment of high risk areas such as the Galveston coast.

Q As a large insurance producer, what role did your company play in preparing your insureds for Hurricane Alicia?

A We did not participate as an individual company. As a member of the Texas Insurance Information Institute and the Texas Catastrophe Property Insurance Association, we supported and encouraged a Hurricane Awareness program. Almost one million brochures entitled, "Texas Coastal Hurricane Preparedness Information" were distributed from key points along the Texas coast (copy attached). Much of this same information was printed on the grocery bags used by supermarkets in coastal areas. In this way, the information was carried home by the customer. Public Service Announcements were prepared for the various media and distributed.

The Institute for Storm Research held a three-day Hurricane Awareness Seminar, primarily for the benefit of community officials. This seminar provided a wealth of information on concepts of hurricane awareness.

Q The processing of claims of Hurricane Alicia uncovered a significantly large number of policies that were misrated largely due to enclosures below the elevated first floor. In your opinion, when did these violations of the NFIP Minimum Flood Plain Regulations occur; at the time of construction or during the term of the policy?

A In our considered opinion, most of these violations occurred after completion of the initial construction and after the initial elevation certification was
obtained. Some enclosures were anticipated as a part of the original plan and some were built as an afterthought on the part of the insured. We are led to believe that one contractor was actually coaching property owners as to how to answer inquiries after the enclosure had been put into place. In other instances, the enclosure was constructed due to ignorance on the part of the property owner.

Q If the violations occurred during the term of the policy, why were they not corrected at renewal time?

A The Agent or Producer is not required to inspect the property either at the time of taking the application or at the time of renewal. Accordingly, the Agent/Producer was probably unaware of the problem. Many Agents/Producers lived in Houston and wrote insurance on property in Galveston or Galveston County. Even after the loss, they did not see the property.

Also, the computer direct-bill process makes it unnecessary for the producer to contact the insured at renewal time unless the premium is not paid. The lack of contact amplifies the problem.

Q When alterations to a structure, covered by a flood policy, are made, who has the responsibility to provide this information in order to update the conditions of the policy?

a) The Homeowner--According to policy condition, the homeowner must notify the agent if changes are made. This is rarely done.

b) Agent--The Agent/Producer might be apprised of the alterations in the unlikely event of an inspection. Otherwise, the only clue an Agent/Producer would have is if the insured increases coverage on the structure.

c) Local Official--We feel that the ultimate responsibility lies with the local official. If building permits and building codes are enforced, the local official should always know of the alterations and the nature of the alterations.

Q At what time during the policy term should this information be made available?

A The information should be made available no later than the time the changes are made. Ideally, prior knowledge of the anticipated changes would allow local officials and/or the Agent/Producer to advise the property owner of potential problems or actual violations.
Q During the rebuilding period after Alicia, did property owners continue to build in the same area, ignoring the potential risk to life and property? Did owners build in compliance with NFIP minimums, and if not, why not?

A Following Alicia, property owners did rebuild in the same areas. Some properties were built in compliance with NFIP minimums, especially where building permits were required and secured. Some community officials allowed the property to be built in such a manner as to exactly reproduce or replace the damaged structure. Easily secured grants, low interest loans and insurance payments were so readily available that there was no deterrent to rebuilding.

The National Flood Insurance Program has instituted a reinspection program whereby a substantial number of the properties damaged in Hurricane Alicia were scheduled for reinspection and inspected after the reconstruction was completed. Unfortunately, this applied only to those structures which had been insured under the NFIP.

Q What role did your company play in the rebuilding period after Alicia?

a) Did you provide information to insureds, who suffered substantial damages, on how to rebuild safely? ANSWER: Only if they requested information.

b) Did you encourage insureds to relocate outside the high risk areas? ANSWER: Only if they requested comments.

c) What role, if any, did you play in assisting local officials in the rebuilding of the severely damaged areas? ANSWER: No assistance was provided on a direct basis. However, we cooperated with the NFIP and the Texas Insurance Information Institute.

Q Isolation is a major problem along the Texas coast. Because of isolation and budget constraints, structures are completed without being inspected by qualified authorities. Alterations and additions are being completed without benefit of a building permit. This only adds to the problem. The obvious solution is, of course, to require and enforce the obtaining of building permits and to have the construction inspected for compliance with building codes as well as flood plain management compliance.

a) What are the problems? ANSWER: So long as the public is convinced that losses will be covered by insurance, government grants or low-interest loans, building will continue. The property owner is able to transfer his risk to someone else.
b) What are the causes? ANSWER: There is a shortage of risk-free land to be developed. The coastal lifestyle is very desirable. Insurance is the cornerstone of credit. With insurance for the peril of wind readily available from Wind Pools or Beach Plans and the Flood Program insuring the risk of flood, there is no deterrent to building in these areas.

c) How can they be resolved? ANSWER: The Coast Barrier Resources Act is a step in the right direction. We have a myriad of separate problems and an array of actions for resolving these problems; community compliance should be rigidly required and rigidly enforced; all program deficiencies should be corrected and all violations abrogated; compliance efforts in other communities should not be undermined.

The Federal Emergency Management Agency is the authority to enforce community compliance by probation, suspension, conditional reinstatement, and subrogation action. Further, they should also consider community-wide verification of insurance rates and recertification of flood insurance policies at renewal.

With regard to individual structures, NFIP can deny insurance on the basis of Section 13.16 and should actively engage in the rerating of individual noncompliance structures. They can also deny claims or collect back premiums on misrated policies. Subrogation action should be taken where appropriate.
THE ROLE OF THE SMALL COMMUNITY AGENT IN THE FIELD OF FLOOD HAZARD MANAGEMENT

John Z. Norris
Norris Insurance Agency, Inc.

Sound flood hazard management programs are the result of a successful marriage of federal, state, and local resources. The key remains the involvement of local community officials. Floods, more often than not, occur in smaller communities with little or no professional planning/engineering staff. Therefore, it is so essential that in these communities, everyone in both the public and private sector work together to build a successful program of flood hazard management. In this scenario, what is the role of the local agent/producer, if any, and how can his resources be used. Mr. Norris of Norris Insurance Agency, located in Baton Rouge, Louisiana, provides some insight into the role of the small agent/producer in the following question and answer format.

Q As an active member of the Producers Services Review Committee, what do you see is the role of the small community agent/producer?

a. In the field of education
b. In the field of local flood plain management
c. In the field of flood disaster response

A a. The role of the small community agent in education primarily relates to helping educate the buyer and prospective buyer of the need for flood insurance.
b. In local flood plain management issues, his role is probably limited to working through his agent's association.
c. In flood disaster response, he can be of real assistance to flood victims not only with individual counseling but also through mass media news releases.

Q Having heard the presentations of Bob Ross (FAIA) and Fred Madsen (USAA), what comments can you offer from the perspective of the smaller producer to what they have said?

A The small agent introduces both advantages and disadvantages into sale of flood insurance. Small agents who write few flood insurance policies are sometimes unfamiliar with procedures, rules, rating and can cause delays in issuance of policies. However, many small-town agents are familiar with flood insurance.
Such agents are good vendors because they are usually much more familiar with risk location, flood geography and community status than their big city cousins. For the large city agent, a major problem is locating the risk on a flood map.

Q What problems in the implementation of the NFIP at the local level have you noticed and what suggestions could you offer for resolution to these problems? (Perspective should be from a producer's standpoint.)

A A major problem of implementing NFIP is conducting a continuous program of education for agents who sell flood insurance. NFIP flood insurance is a complicated, intricate and detailed program to work with. This is necessarily so because flooding in and of itself is a complicated physical event. NFIP was constructed by congress on principles which differ greatly from those of commercial insurance programs. Finally, NFIP has a history of changing its program regularly and frequently. It is a difficult insurance product for a salesman to keep current on.

Q Do you have any suggestions for improving the overall success of the NFIP at the local level?

A The success of the NFIP can be improved by improving communications between the parties. NFIP needs better communications with both agents and flood plain managers. Flood plain managers need to communicate more with agent groups and associations. Agents need better communication with the buyer of flood insurance.
LIMITED-DETAIL FLOOD INSURANCE STUDIES CONDUCTED BY THE U.S. GEOLOGICAL SURVEY

Ernest D. Cobb
U.S. Geological Survey

Introduction

The Federal Emergency Management Agency (FEMA) required a less costly and quicker means of conducting flood studies for insurance purposes than those methods used in the detailed flood studies. In February 1984, the U.S. Geological Survey (USGS) entered into an agreement with FEMA to evaluate 2,349 communities for the application of limited-detail study (LDS) methods. This paper discusses the LDS methods that were considered, the results of the evaluation, and present USGS-LDS activities.

Limited-Detail Study Methods

Eight LDS methods were considered during the community evaluations. They are: 1) simplified step backwater; 2) historical floods; 3) slope conveyance; 4) depth frequency; 5) reservoirs; 6) information from previous studies; 7) tidal flooding; and 8) profile interpolation.

Common to all of the limited-detail studies are the following:

• The profile and inundation boundaries are determined only for the 100-year flood.
• No floodway is computed.
• The summary report is greatly reduced relative to that required for the detailed studies.
• Profiles must be tied to a datum, usually the National Geodetic Vertical Datum of 1929.

When more than one LDS method would provide a suitable profile, the choice of method is based on an assessment of the level of development in the flood plain, a comparison of the cost of applying the LDS methods, and the expected accuracy of the methods. For highly developed areas, it was a goal of the evaluations to select the most accurate LDS method available. The historical data
method generally provides the most accurate results and is a relatively low-cost method to apply where available high-water mark information is sufficient to define a flood profile at, or near, the 100-year level. The simplified step-backwater method is a high-accuracy method but it is usually the most expensive to apply of the several methods. Combinations of the methods may be applied in many studies. A description of the various LDS methods follows.

**Simplified Step-Backwater Method**

This method is most similar to the method commonly used in the detailed flood-insurance studies. In addition to those differences that are common to all LDS methods, cross sections are spaced as far apart as possible, few or no sections are obtained for profile convergence purposes, cross sections are interpolated where the channel is fairly uniform or gradually converging or diverging, and bridge and culvert configurations are superimposed on valley cross sections where the valley section is fairly uniform through the bridge or culvert area. Slope-conveyance methods are often used to estimate starting elevations for the simplified step-backwater method.

**Historical Floods Method**

This method utilizes historical flood information. This information may be available in reports or on maps that have been prepared for major floods, from high-water marks, from gaging station data, or from indirect flood-discharge measurements made in the study area. Historical flood information may often be found in USGS flood or data reports, or in USGS files. The information may also be available in reports or files of other agencies. In all cases the information must be evaluated for accuracy and applicability to the present conditions.

Historical information may be used directly if it approximates a 100-year flood. Otherwise, the 100-year flood profile will have to be determined by interpolation or extrapolation. Sometimes historical information is not adequate in itself to define a 100-year flood profile. In this situation, the historical information may be used to define water-surface slope and roughness coefficients or to confirm a profile developed by another method.

**Slope-Conveyance Method**

This method is similar to the simplified step-backwater method. A primary difference is that the energy equations are not balanced. This method is used on long, fairly uniform reaches, at the start of a simplified step-backwater study reach, or with historical information.
One of the problems with this method lies in the estimation of the energy slope. This can be estimated with information from high-water marks, historical flood profiles, discharge measurements, bed slope, or, generally as a last resort, from topographic maps.

**Depth Frequency Method**

This method was recommended for use in the community evaluations for only those areas for which a depth-frequency relationship had already been determined. Many depth-frequency studies determine the height of the 100-year flood profile above the elevation of the 50% flow duration or the height above the average streambed profile. These heights are then physiographically regionalized and related to drainage area or other profile characteristics.

The depth-frequency method is not applicable at bridges, culverts, contractions, in areas of backwater from downstream obstructions, or in channels modified by man's activities. Backwater elevations for manmade constrictions or obstructions must be computed through the use of appropriate hydraulic equations. The method should be used only for channels for which the depth-frequency relationship was developed. For example, if the relationship was developed from information obtained from alluvial channels, this relationship should not be applied to channels in other morphological settings.

The base profile used for application of the depth-frequency method can usually be established by surveying a low-water profile through the study reach. This profile will often approximate the water-level elevation of the 50% duration flow. A rough approximation of the base profile can be obtained from a topographic map if the contours are fairly close together. The contours at stream crossings generally represent low-flow elevations. However, owing to inaccuracies in most topographic maps, field surveys are usually needed to make the necessary elevation adjustments.

**Reservoirs Method**

There are two approaches using this LDS method. The first is used where 100-year flood elevations are needed in the reservoir area. In this approach, a rating is determined for the outlet from the reservoir. The stage for the 100-year flood peak is then determined and that stage is used to define the 100-year flood elevation around the reservoir. It is assumed in this case that reservoir
storage is small and has little affect on the 100-year flood peak. The method is not applicable where this assumption is significantly violated.

The second approach is used where 100-year flood stages are needed downstream from a reservoir. Flows must be routed through the reservoir and the 100-year flow downstream from the reservoir determined. This method is not used as an LDS method downstream from large, complex reservoirs.

**Information From Previous Studies**

Information is obtained from other studies. This may be information resulting from model or other types of studies. The information must be evaluated for its adequacy and applicability to current conditions. If the profile from this other information cannot be tied to a datum, it may still be of value for estimating water-surface slopes and roughness coefficients.

**Tidal-Flooding Method**

This method is used only in coastal areas that are protected from significant wave action. The method uses 100-year tide elevations provided by other agencies such as the National Oceanic and Atmospheric Administration. These elevations are then applied to maps. This method was recommended in the community evaluations for only two States.

**Profile-Interpolation Method**

This method is used to interpolate the 100-year profile between stream segments where the 100-year profile is already defined. This method is applicable generally only for short stream segments, the length depending on the uniformity of the channel and channel slopes.

**Evaluation Results**

Evaluations were made of 2,349 communities for the application of LDS methods. The evaluated communities are located in 38 States (see figure 1). Pennsylvania had by far the largest number of communities with 817 communities evaluated. The State with the next largest number of communities evaluated was Mississippi with 151.

Of the 2,349 communities evaluated, it was determined that LDS methods could be used in 1,710 of the communities. Detailed studies were considered appropriate for 62 communities and no studies were considered appropriate for 577 communities.
In the 1,710 communities for which LDS methods could be applied, 9,390 miles of streams were estimated to be appropriate for the application of LDS methods. The estimated cost of conducting studies in these communities was about $23 million or about $2,500 per mile of stream studied. Many of the stream segments that were evaluated were less than one mile long. These short stream segments tend to elevate the cost per mile of these studies.

The following lists the length of stream for which various LDS methods could be applied.

<table>
<thead>
<tr>
<th>LDS method</th>
<th>Percent of total stream length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simplified step backwater</td>
<td>40</td>
</tr>
<tr>
<td>Historical method</td>
<td>12</td>
</tr>
<tr>
<td>Slope conveyance</td>
<td>1</td>
</tr>
<tr>
<td>Depth frequency</td>
<td>11</td>
</tr>
<tr>
<td>Reservoirs</td>
<td>1</td>
</tr>
<tr>
<td>Previous studies</td>
<td>3</td>
</tr>
<tr>
<td>Tidal flooding</td>
<td>1</td>
</tr>
<tr>
<td>Profile interpolation</td>
<td>1</td>
</tr>
<tr>
<td>Combinations of methods</td>
<td>30</td>
</tr>
<tr>
<td>and other methods</td>
<td></td>
</tr>
</tbody>
</table>

**Present USGS LDS Activities**

The USGS has entered into an agreement with FEMA to begin work on about 515 communities in 1985 using LDS methods (see figure 1). Most of these studies are to be completed by September 1986. The remainder will be completed in 1987.

**Summary**

Limited-detail studies include eight methods. They are: 1) simplified step backwater; 2) historical floods; 3) slope conveyance; 4) depth frequency; 5) reservoirs; 6) information from previous studies; 7) tidal flooding; and 8) profile interpolation. The simplified step-backwater method was found to be the most appropriate for use on about 40% of the total stream lengths for which
LDS methods could be applied. The average cost of application of LDS methods is about $2,500 per mile of studied stream length. The USGS is beginning studies in 515 communities in 1986. All of these studies will be completed by 1987.

Figure 1. — Number of communities evaluated for the application of limited-detail study methods and the number of communities where limited-detail studies are being conducted.
IMPLEMENTATION OF NONSTRUCTURAL FLOODPLAIN MANAGEMENT MEASURES BY THE U. S. ARMY CORPS OF ENGINEERS

Jerry L. Greer
Ohio River Division
Corps of Engineers

Introduction

The evolution of flood damage prevention measures in the United States portrays a continuing effort to separate flood waters from people and their possessions, all within the framework of an ever-changing set of circumstances. During the early development of this nation, principal concerns were with the most fundamental of human objectives such as dependable food supplies, shelter from the elements, and security from physical danger. The initial development of water resources related directly or indirectly to these needs in the context of an expanding country, and focused mainly on water transportation and water supply. Population centers inevitably clustered along river valleys and in floodplains. Uncontrolled clearing of forested areas for agricultural uses and grading and drainage activities for urban uses changed rainfall-runoff characteristics to compound an already worsening proliferation of unwise uses of floodplain lands.

At this point, flood problems became recognized as a significant concern of the federal government. Early solutions to flood problems were almost always based on the premise that flood waters should be controlled to protect areas of the floodplain for developmental purposes. However, ultimately it became obvious that flood control projects could not protect against all floods, especially if uncontrolled development continued. It was apparent that actions designed to influence land use decisions must become an added dimension to public policy on floodplain management. "Floodplain management," as used herein, is a comprehensive term which covers a full range of actions encompassing both structural and nonstructural measures.

History of the Corps of Engineers in Water Resources Development

The Corps of Engineers has played a major role in the development of water
resources in this nation. As early as 1824, the Congress established a Board of Internal Improvements to plan a national transportation system of roads, canals, and waterways. Various River and Harbor Acts and, later, Flood Control Acts have provided authorization for the Corps' water resources program. The Corps' mission had to do primarily with navigation improvements until 1879, when the Mississippi River Commission was created with flood control as an added function. Flood control on the Mississippi River, however, remained incidental to navigation until 1917 when the first specific flood control legislation made flood control, by law, as much a part of the Commission's work as navigation.

The first nationwide survey of multiple-use possibilities for development of the nation's rivers was assigned to the Corps by Section 308 of the 1927 River and Harbor Act. In the next decade, the Corps prepared some 200 "308 Reports" outlining possible developments for purposes of navigation, flood control, irrigation, and hydroelectric power. These studies are generally acknowledged to have provided the basis for much of the intensive multiple-purpose water resources planning and development over a period of more than 50 years. Public support for large annual expenditures on conventional flood control projects waned with the recognition that the rate of annual flood damages continued to increase in spite of these expenditures. These concerns were reflected by Section 206 of the River and Harbor and Flood Control Act of 1960, which authorized the Corps to provide information, technical planning assistance, and guidance to other federal and non-federal entities to identify the magnitude and extent of flood hazards, and to assist them in planning for wise use of floodplain lands. This was the genesis of the Corps' Flood Plain Management Services program. The wise use concept added a new dimension to flood plain management and became the forerunner of Section 73 of the Water Resources Development Act of 1974, which requires that nonstructural alternatives for flood damage reduction be considered in the project formulation process.

**Status of Implementation**

The Civil Works mission of the Corps of Engineers is very complex and comprehensive. It is funded under Public Works Appropriations and is not a part of the Defense budget. Under the Command of the Chief of Engineers, programs are executed by military and civilian staffs in 11 division offices and the 36 subordinated district offices. Geographical areas of responsibility
are separated by drainage divides and river basin boundaries. Policy guidance comes from the headquarters office in Washington. However, the Corps has a policy of decentralization that provides for authority to be delegated to commanders at division and district levels, in order that differing needs and perspectives of the various regions of the country can be considered. The currently changing emphasis in floodplain management from structural measures to nonstructural measures has not yet resulted in clearly defined procedures for the implementation of plans which include nonstructural measures as a principal component. This does not mean that projects utilizing these components are not being formulated, a high degree of originality is being used by Corps planners to develop locally acceptable solutions to flood problems within established financial and administrative constraints.

Seminar on the Implementation of Nonstructural Measures

The Civil Works Directorate of the Corps of Engineers hosted a seminar on the Implementation of Nonstructural Measures at Fort Belvoir, Virginia, in November of 1982. The seminar focused on the need for new initiatives in research, information and experience transfer, procedural guidance, and policy issues. Discussions gave strong support for equal consideration of structural and nonstructural flood plain management measures. The seminar was attended by representatives of federal, state and local agencies and the private sector. The Corps was represented by participants from 40 of the 47 district and division offices. The proceedings were published and distributed in July of 1983.

A Corps committee was assembled in July of 1984 to identify key issues and problems discussed at the seminar and develop recommendations for follow-up actions needed to enhance the implementation of nonstructural measures in Corps feasibility studies. Committee members represented Corps headquarters, three division offices and four district offices. Recommendations of the committee are not yet final. However, as a member of that Committee, I will enumerate and discuss some of the primary issues.

Definition of Nonstructural Flood Plain Management Measures

A universally accepted definition of "nonstructural measures" has not yet been developed. A part of the difficulty in defining the term stems from the fact that floodproofing actions are sometimes not clearly distinguishable from structural measures. A clear separation between the two terms becomes critical when considering an item of construction such as a ring levee. If it protects only one to two houses, it is considered a nonstructural measure and, as such,
has no requirement for freeboard. However, if the ring levee is extended to provide protection to a few more houses, it becomes a structural measure. The difference affects not only the design criteria, but also qualification for (80/20) cost-sharing under Section 73.

Inventory of Nonstructural Measures

A definitive consolidation of information on nonstructural measures completed or recommended in various Corps projects and plans is essential. It is important for Corps planners to know what has been done by others and how their efforts have been received.

Emergency Preparedness Planning

Corps participation in the implementation of flood warning systems or temporary evacuation plans, as elements of an overall floodplain management plan, is generally limited to the provision of technical assistance and planning guidance to appropriate government levels, and to the provision of equipment devoted exclusively to this purpose. Corps assistance in the development of these measures over the last decade has been provided as a technical service under the Flood Plain Management Services program (Section 206, River and Harbor and Flood Control Act of 1960) or the Planning Assistance to States Program (Section 22, Water Resources Development Act of 1974). The effectiveness of emergency preparedness planning as an element of comprehensive floodplain management plans would be maximized if the flood warning and emergency evacuation portions of nonstructural plans could be implemented as early-action items. Under current procedures, none of the plan is funded until the total plan is authorized by Congress and monies are made available. Another significant problem centers on the need for uniform guidance on the evaluation of flood damage reduction benefits specifically applicable to emergency preparedness measures.

Floodplain Regulations

Floodplain regulations may be required as a part of a flood control project. However, adoption and enforcement of regulations for floodplain management are entirely local responsibilities. Local interest may be required to adopt and enforce such regulations as a necessary component to the protection of the federal investment, or to achieve expected project benefits.

Permanent Floodplain Relocation/Evacuation Projects

Policies and regulations for planning and implementation of Corps projects are not easily adapted to meet the special requirements of flood plain reloca-
tion/evacuation measures. The following issues have bearing on such projects.

The reduction of flood damages borne by floodplain activities is not claimed as a benefit of evacuation or relocation because they are already accounted for in the fair market value of floodplain properties. These measures are difficult to justify economically because the costs are high.

Uniform implementation responsibilities and procedures for field management of such projects have not yet been established. These critical items can be undertaken by the local sponsor or by the Corps.

Corps policies and regulations on real estate acquisition and disbursement of project funds are not designed to meet the special needs of relocation/evacuation projects. Currently, the Corps cannot provide advance financing for the purchase and resale of optional flood-free relocation sites.

A clear distinction between "financial costs" and "economic costs" is a concern in the application of existing guidance to the evaluation of benefits. "Financial costs" require no economic justification because they are assumed to be offset by equal benefits. Remaining "economic costs" must be shown to be justified by calculated benefits.

Voluntary vs. Mandatory Participation

Implementation procedures are not clearly established in regard to whether permanent relocation/evacuation and floodproofing measures are voluntary or mandatory. There appears to be a legal and policy consensus that implementation of an authorized evacuation/relocation project is mandatory (eminent domain can be applied), but floodproofing of individual homes is voluntary.

Level of Protection for Nonstructural Measures

Comprehensive guidance for establishing appropriate levels of protection for nonstructural measures should be formulated. Current guidance establishes no specified minimum level of protection for nonstructural plans. The level of protection for individual floodproofing measures may be selected on the basis of maximizing net benefits. This procedure can result in the selection of less than 100-year level of protection for some measures, which would be inconsistent with the requirements of the National Flood Insurance program, because the protected areas still would be considered flood-prone.

Conclusion

We have reached an awareness that the contribution of nonstructural measures to the objective of flood damage reduction is not only a function of how these measures relate to the physical aspects of a given flood problem, but
also to what extent the benefiting public understands and accepts them. Future success in the implementation of nonstructural projects will depend on the acceptance of an actively involved public. This challenge affects the states and local levels of government, as well as the Corps of Engineers and the rest of the federal establishment. The Association of State Floodplain Managers is a dynamic association of professional floodplain managers representing all levels of government and the private sector which can play an essential role in the achievement of the numerous objectives of this critical period.

References

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Steinberg, Bory

Yoe, Charles
SOIL CONSERVATION SERVICE ASSISTANCE TO FLOODPLAIN RESIDENTS

Phillip A. Renn
USDA Soil Conservation Service

Introduction

Floodplain management assistance to reduce upstream flood damages is provided through numerous Soil Conservation Service (SCS) programs. Some of the efforts, such as floodplain management studies, river basin studies, and conservation operations provide only technical information. Programs offering both technical and financial assistance are the Watershed Protection and Flood Prevention Act (PL-566) and Resource Conservation and Development (RC&D). Most of the assistance under these programs goes directly to units of government and indirectly to the actual residents living in the floodplain.

Flood Plain Management and River Basin Studies have been conducted on 1) breach routing and inundation mapping below dams, 2) hydraulics and hydrology in areas not covered by flood insurance studies, 3) stormwater management modeling, and 4) project planning. Each study is carried out in accordance with a plan of work developed by the local government and SCS. River Basin Studies have been used for large river systems where other resource problems exist which need to be evaluated.

Flood prevention measures under the PL-566 and RC&D programs are planned, designed, and constructed to reduce flood damages on residential, commercial and industrial properties, railroads, roads, utilities, and agricultural crops in watersheds smaller than 250,000 acres. Historically, structural measures such as dams and channelization have been favored, but nonstructural measures can also be used.

Flood Warning System

In Connecticut, the Soil Conservation Service has undertaken a special study and pilot project to test the use of a flood warning system and individual assistance to reduce flood damages. SCS and the Connecticut Department of Environmental Protection (DEP) are funding a system of 21 automated precipitation gages for a statewide flood warning network. In addition, five precipita-
tion gages and two river gages will be installed for two local warning systems—one on the Yantic River in Norwich and one on the Quinnipiac River in Southington.

The major components of the automated flood warning system include precipitation gages, river gages, radio transmitters, radio receivers, and a microcomputer. The gages will continuously monitor and instantly transmit data to receivers located at the municipal police station and at a National Weather Service River Forecast Center. There, the data will be processed using a microcomputer system. Along with the hardware, SCS has contracted with the Connecticut Council on Soil and Water Conservation to conduct flood audits on all floodplain properties in the two local areas. The two areas receive almost $500,000 in damages on the average annually. The flood warning system and flood audits are expected to reduce the damages by 10-30%.

Flood Audits

Individual flood audits focus on providing flood preparedness training to potential flood victims in a local community. The audits are one way to give residents information on the corrective actions that they can take to reduce their flood losses. Without individual flood audit assistance, most people will only know that a flood will occur at a predicted time and it may reach a certain height at the gage. They will not know how a flood of this height at the gage will affect their individual property nor what action to take to reduce flood damage.

The property owners are interviewed to obtain structural and physical information for the building (see Table 1). After the interview, the flood heights and their relationship to the individual building are identified and added to the Flood Audit Interview Worksheet. The action items for each flood height are identified and shown on the Sheet on Prescribed Actions (Table 2).

When a person who has had a flood audit is alerted to a predicted river flood stage, he or she can use the information on the worksheets to:

1) Determine whether or not they will be affected by the flood stage predicted.
2) Utilize each additional hour and minute gained through the ALERT system in preparation for the flood.
3) Take damage reduction actions for a given flood stage as specified in the list of recommendations resulting from the individual flood audits.
4) Evacuate in a timely manner using a predetermined route.
## TABLE 1
FLOOD AUDIT INTERVIEW WORKSHEET

<table>
<thead>
<tr>
<th>Address</th>
<th>Occuptant</th>
<th>Contact</th>
<th>Bldg. Owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telephone</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Frequency Flood</th>
<th>10 Yr.</th>
<th>30 Yr.</th>
<th>50 Yr.</th>
<th>100 Yr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Probability</td>
<td>10%</td>
<td>3.3%</td>
<td>2.0%</td>
<td>1.0%</td>
</tr>
<tr>
<td>Inches Rain in 24 Hours</td>
<td>5.0 in.</td>
<td>5.9 in.</td>
<td>6.3 in.</td>
<td>7.1 in.</td>
</tr>
<tr>
<td>Yantic River Stage</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floodwater Elevation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floodwater Depth</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flood Stage At Which Damage Starts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Structure - house - building - ___ stories - _______
___ car garage - shed - _______
FOUNDATIONS - stone w/conc - conc - conc blk - brick - conc slab - _______
WALLS - conc - conc blk - brick - frame - _______
BASEMENT - full - partial - conc/dirt floor - finished - _______
Any evidence of stress? (buckles, cracks)

WATER - public - well (shallow - deep) (submersible pump - reg) -
SEWAGE - public - private (tank-leachfield - _________) -
FURNANCE - elec - oil - gas - wood - hot water - air -
WATER HEATER - elec - oil - gas -
FUEL Tanks - oil - propane - gasoline - diesel -
- in-ground - inside - outside - anchored
DRAINS - foundation - floor - yard - curtain -
DISCHARGE - ground - surface - storm sew - sanit sew
Any flood related problems?

FLOOD PREVENTION MEASURES
- sump pump - sandbag - shield - sealant -

ENTHUSIASM (-) (-/+)(+/-)(+) (+)
<table>
<thead>
<tr>
<th>ITEM</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>O A 1ST</td>
<td></td>
</tr>
<tr>
<td>U S H M</td>
<td></td>
</tr>
<tr>
<td>T E F E O</td>
<td></td>
</tr>
<tr>
<td>S M L I B</td>
<td></td>
</tr>
<tr>
<td>I E O G I</td>
<td></td>
</tr>
<tr>
<td>D N O H L</td>
<td></td>
</tr>
<tr>
<td>E T R T E</td>
<td></td>
</tr>
</tbody>
</table>

1. Bsmt fl to 1st fl | X | X | X | X |
2. 6/82 Flood Depth | X | X |
3. 1st Floor Ent |       |
4. Bsmt Ent |       |
5. Bsmt Wind |       |
6. H2O Line/Meter |       |
7. H2O Pump |       |
8. H2O Heat |       |
9. Gas Line/Meter |       |
10. Elec Line/Meter |       |
11. Fuse/Cir Brk |       |
12. Tel Line |       |
13. Sewage Line |       |
14. Toilet |       |
15. Sink/Tub/Sh |       |
16. Furnace & Burner |       |
17. Fuel Tank/Line |       |
18. Tank Intake/Vent |       |
19. Air Conditioner |       |
20. De/Humidifier |       |
21. Wash/Dry (g)(a) |       |
22. Refrig/Freeze |       |
23. Stove/Oven |       |
24. TV/Stereo |       |
25. Furniture |       |
26. Other |       |

(X's MEAN NOT APPLICABLE)
<table>
<thead>
<tr>
<th>Item</th>
<th>Location</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuse Box</td>
<td>Basement</td>
<td>No Action</td>
</tr>
<tr>
<td>Appliances</td>
<td>Basement</td>
<td>No Action</td>
</tr>
<tr>
<td>Misc. Contents</td>
<td>Basement</td>
<td>No Action</td>
</tr>
<tr>
<td>Carpets</td>
<td>Basement</td>
<td>No Action</td>
</tr>
<tr>
<td>Canning Jars</td>
<td>Basement</td>
<td>No Action</td>
</tr>
<tr>
<td>Floor Drain</td>
<td>Basement</td>
<td>No Action</td>
</tr>
<tr>
<td>Hot Water Heater</td>
<td>Basement</td>
<td>No Action</td>
</tr>
<tr>
<td>Furnace</td>
<td>Basement</td>
<td>No Action</td>
</tr>
<tr>
<td>Stairwell</td>
<td>Basement</td>
<td>Block Floor Drain</td>
</tr>
<tr>
<td>Bag Circulator Motor</td>
<td>Bas...</td>
<td>No Action</td>
</tr>
<tr>
<td>Sand Bag Burner and Sand</td>
<td>Bag Basement Base...</td>
<td>16 FEET</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14 FEET</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 FEET</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 FEET</td>
</tr>
</tbody>
</table>

TABLE 2

PRESCRIBED ACTIONS TO TAKE FOR THE GIVEN FLOOD STAGES
THE EVOLUTION OF NONSTRUCTURAL TECHNIQUES IN COMPREHENSIVE FLOODPLAIN MANAGEMENT PROGRAMS

James E. Goddard
Consulting Engineer

The nation's first full-scale regional program of floodplain management was launched in 1953 in the Tennessee Valley. Initially it involved floodplain regulations; later other nonstructural measures were added as complements to flood control structures to reduce flood damage potential and urge wise use of floodplains. The success in the Tennessee Valley led to our national program that is growing in effectiveness.

Regional and urban planning was only three decades old in 1953 and many people questioned the appropriateness of such an approach. Just as important was the historical flood-structure-only school of thought, in which floodplains had been subsidized for years. That had cost many billions of dollars but had been unable to reverse the nation's increasing flood damage potential. This was the setting when the new management program was initiated. It was to have people consider the adoption of self-restraints that would control and sometimes restrict use of their lands and related resources, along with the consideration of structural protection heavily subsidized by the federal government.

Major criteria set out for floodplain regulations perhaps had, and continue to have, the greatest effect on comprehensive floodplain management. How a few of those criteria were determined is presented herein. It was decided early that the following must be accomplished for a successful program:

1) States must be an active partner in the local-state-federal team for an effective program.
2) Engineers and town (regional) planners must cooperate closely for the best acceptable solution to local flood problems.
3) Officials and the public must understand the problem and be aware of alternate solutions.
4) An intermediate between "no use" and full use" of the floodplain must be determined. It must permit wise use and also be acceptable.

Below each of these goals is discussed in more detail.
Local-State-Federal Cooperation

Many of the floodplains are too large for local government or even state government to handle alone. Furthermore, it is neither feasible nor desirable for the federal government to act independently. An increased degree of cooperation between local, state, and federal agencies and individuals was considered a necessary element in proper management.

States have statutory powers and have granted many of those powers to local governments. They should play an active role in shaping and administering state programs in accordance with their respective state constitutions and organization. Local governments must play the major role because they have been granted necessary statutory powers and they can insure that the solution is appropriate to their problem.

Federal technical and financial assistance, encouragement, guidance, and related activities should be channeled through state agencies. This would lead to greater confidence of local officials and public, better administration, and greater continuity of the program. This policy was adopted and followed.

Engineers-Planners Cooperation

The expertise of planners and the technical expertise of engineers must be coordinated for the best solution to flood problems. Calling on both professions and obtaining input from each in a timely fashion was arranged early in the program. This cooperation resulted in actions acceptable to the public and to the courts.

Public Understanding of Problem and Possible Solutions

Officials and the public must understand the problem and all alternate solutions in order to select and implement the best solution. This "informed public" is even more important when breaking away from the limited, traditional approach that had been found lacking.

Nomenclature for Understanding

One of the actions to change and broaden the thinking was to adopt a new and more descriptive term or name for the comprehensive concept. The term "floodplain management" was coined as a part of coordinating efforts of local, state, and federal officials, water resource planning engineers, geographers, planners, economists, lawyers, foresters, recreation specialists, naturalists, and other officials and disciplines concerned with an overall comprehensive approach. It appeared to be the most acceptable (or the least objectionable) to the various groups and interests. It is now widely accepted.
The Legal Question

The skepticism concerning zoning or regulating areas for flood hazards had to be overcome early. Court cases were scarce and generally unknown. Most communities did not have, nor could they afford, full-time attorneys. Since few of the community attorneys were versed in this phase of the law, it was decided to give advice in a general way and be more specific upon request. A brief legal treatise with ample references was prepared in layperson's language. It stated the case and finally declared that "courts have upheld the regulation of land use for the prevention of flood damages." This article was printed in the National Civic Review in 1961. Thousands of reprints were distributed in the Tennessee Valley and nationwide. This article proved very effective.

The Flood Report

Another action was to design a simplified type of report that could be understood by lay as well as technical people. This went counter to tradition in presenting the engineering data. Technical terms were held to a minimum. The best data available were included for general interpretation and use. Maps showing areas inundated by various floods, profiles showing elevation of the floods, photos showing flood heights on prominent structures, and a short history of flooding at the site were among the data presented in the reasonably brief reports. The reports were distributed to respective officials and individuals. They were explained and discussed to insure an understanding of the problem.

Following presentation of the basic flood report, possible alternate solutions to the flood problem were presented and explained. These were described and illustrated in booklet or leaflet form. Planning and engineering assistance and guidance were given to state and local officials to help them choose the appropriate approach for the community. A floodplain regulations solution was generally the first action taken. A comprehensive solution often followed--sometimes with structures--after much more study and time.

Wisely Limiting Use of FloodPlains

Many advocated that the floodplains should not be developed, but be kept clear and open to prevent heavy losses from flooding. Others contended that natural resources of flood plains were too great to sacrifice through no use. Urban planners, engineers, economists, lawyers, geographers, administrators, officials of several states and several communities, and authorities in a few
universities and federal agencies were consulted. These discussions indicated that the "zero" approach could result in the inefficient use of the floodplains. The need for a reasonable, intermediate approach with a judicial balance of development was suggested.

Floodways

The concept which evolved from this process was an intermediate that allowed encroachment onto the floodplain. The decision was to preserve a floodway to accommodate nature's flood waters and require the elevation or floodproofing of structures outside the floodway. The floodway was to be the channel and that portion of adjacent floodplains necessary to carry the specified flood without increasing flood elevations significantly.

The criterion for "significant increase" determined to be a reasonable amount was "no more than one foot." The number "one" did not suggest an accuracy or degree of guidance that a fraction or fractions of a foot might connote. It related realistically to the engineering judgment applied in hydrologic and hydraulic computations. It was to be a minimum criterion intended as a regional standard, recognizing that there were urbanizing areas where elements might indicate a smaller rise might be appropriately considered. The criterion has proven to be reasonable, justifiable, and acceptable.

Selecting Flood Magnitude for Regulations

The devastating effects of failing structures (levees, walls, dams) are quite different from the inundating effects of gradually rising flood waters. That is a major reason why a flood of lesser magnitude can reasonably be considered for regulations.

In selecting a flood criterion it was recognized that an excessively high level would result in wasted resources, but an insufficient level would increase the probability of costly damage in the future. It was believed a "regional flood" based on flood experiences in the immediate region could be reasonably expected to occur at the subject site. Also, local people, officials, and decision makers would be more likely to understand and accept a flood of such magnitude. For those reasons, a regional flood was selected.

Developed at a time before the highly theoretical and largely misunderstood frequency designation came into common use, this regional flood was sometimes a little higher than the statistically derived 100-year flood minimum standard selected in 1966 as part of the national program.
A Larger Flood for Greater Safety

In addition to basing regulations on this regional flood, it was thought that users should be aware that larger floods could be expected. Therefore, it was decided to present data (elevations and areas that would be inundated) for the Tennessee Valley Authority’s "maximum probable flood"—the flood related to designing flood control structures by TVA. This was to alert users to the probability of greater floods and provide a guide for those that wished to accept very little, if any, risk.

Floodproofing

Floodproofing was another element of floodplain management given early attention. In order to better understand the possible role of floodproofing in comprehensive floodplain management, assistance was given the University of Chicago and one of its graduate students (John R. Sheaffer) to make a study. That report, "Flood Proofing," and a later publication prepared by Sheaffer, "Introduction to Flood Proofing," have been used nationwide and extensively. Knowledge gleaned from the study was used in integrating floodproofing into the Tennessee Valley program.

Corps of Engineers Criteria

The U. S. Army Corps of Engineers (Corps) started its nationwide Flood Plain Management Services program late in 1966. The successful experiences in the Tennessee Valley were reviewed and most were incorporated into the Corps' effort. The concept name of floodplain management was used to denote the broadened approach. The brief, simplified type of report in layperson's language adopted was similar to that of TVA. The floodway concept with the "significant increase" criterion of "no more than one foot" was made a part of the program.

The selected flood chosen by the Corps was termed "Intermediate Regional Flood" to connote a flood that was intermediate between lesser floods and the large damaging floods that could reasonably be expected in the region. The 100-year flood was chosen for this, but it was identified on maps and profiles as an intermediate regional flood. It related reasonably close to, but varied somewhat from, TVA's regional flood. The Corps' standard project flood was used to alert users to the probability of greater floods.

FEMA (FIA) Criteria

The Federal Insurance Administration (now FEMA) later established some national minimum requirements for federal flood insurance eligibility. Those
included adoption of floodplain regulations meeting certain minimum standards. The terminology of floodplain management, a base flood of 100-year frequency, and the floodway concept using the "no more than one foot" criterion were adopted.

Review of Criteria

Congressional committees have reviewed the 100-year flood and the "no more than one foot" criterion for floodways two or more times. The criteria have also been reviewed and sometimes challenged by some officials and communities. The reasonableness and acceptability of the criteria have withstood all such reviews. However, some states and some communities in other states have recognized the "minimum" intent of the "one foot" standard and adopted more restrictive standards.

Further information concerning the evolution of floodplain management criteria can be found in TVA's report, "Flood Plain Management--The TVA Experience," December, 1983. Also, a history of the "Corps And Flood Plain Management" may become available in the next several months.
FLOOD INSURANCE AND ITS RELATIONSHIP TO FLOODPLAIN MANAGEMENT

Nicholas Lally
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Evolution of the Management Program

The National Flood Insurance Program has had the greatest impact of any federal program in developing an awareness of the need to manage our nation's floodplains. It involves all three levels of government--local, state, and federal--and has, therefore, engendered many conflicts over regulations, standards, and policies. The national impact took many years to evolve and its effectiveness has been hampered by some of the policy decisions in the political arena.

Flood insurance first became a national topic in 1951 following a disastrous flood along the Missouri River. President Truman asked the insurance industry to re-examine its traditional position of not underwriting flood damages. In response, the Insurance Executives Association appointed a committee to study the problems of floods and flood damage. In May of 1952 a report was published with the conclusion that insurance companies:

- could not prudently engage in this field of underwriting.
- It is our considered opinion that insurance against the peril of flood applicable to fixed property cannot successfully be written and that any specific promise of indemnity for loss by flood must therefore be regarded as in the nature of a subsidy or relief payment, which are quite outside the scope of private insurance....
- As a long-range program, it appears that an accelerated flood control program supplemented by such relief payments as are necessary on account of flood damage would be more in the interest of the public than a program of so-called 'flood insurance' which would not be self-supporting.
In August of 1955, rainfall associated with Hurricanes Connie and Diane created catastrophic losses in the northeastern United States. These disasters, coupled with a December, 1955, storm along the California coast, resulted in strong political pressure on the Congress for disaster assistance. Once again the insurance industry was asked to re-examine its position on flood damages and it quickly responded with the same conclusion as in 1952.

The Congress then proceeded to enact its own program called the Federal Flood Insurance Act of 1956. This legislation intended to provide reimbursement to individual homeowners who suffered flood losses up to a maximum of $10,000. Despite the fact that the legislation was enacted, funds were never provided because there were those in Congress who recognized that this was a "giveaway program"—without some control on construction in the floodplain, it would be encouraging more spiraling flood damages and further raids on the federal treasury.

In 1966, the President's Task Force on Federal Flood Control Policy recommended that the feasibility of insurance be studied with rates to be established to reflect annual potential damage, and an "occupancy charge" that would preclude new development unless the advantages were expected to equal or exceed the total social (public and private) cost. These concepts were incorporated in a pilot program which led to the creation of the National Flood Insurance Program in the Housing & Urban Development Act of 1968. This new program had a "double-barrel" approach—indemnification for those suffering damage was contingent on the local authority adopting criteria that would assist in reducing damage caused by floods and guide new construction away from flood hazard areas. It was hoped that this approach would eventually make the program self-supporting as the subsidized portion of the annual losses became a smaller and smaller percentage of the total insurance pool.

NFIP

For the first five years of its operation (1968-1973), as a purely voluntary program, the National Flood Insurance Program had little national impact. Relatively few flood-prone communities had adjusted building codes and construction practices to gain eligibility for federally subsidized flood insurance. In spite of the low subsidized rates, few owners purchased flood insurance when their communities became eligible for coverage during the period between 1968-73.

During this period, Congress made some changes which to this day are being
debated as having a negative impact from a flood plain management perspective. These were done in the 1969 amendments to the program as follows:

1) The word flood in the legislation was to include the phenomena called "mudslides." This action was the result of severe storms in California which, combined with unstable soil conditions, resulted in earth movement down a slope, often carrying with it existing structures or covering them with a "sea of mud." To my knowledge, federal land use criteria for these conditions have never been promulgated, but some counties have made a major effort in trying to control the problem. This issue, along with alluvial fans and high-velocity shallow flooding, will be noted further in this presentation.

2) The second debatable change in the law was making available flood insurance for existing structures in an area that had not been studied for actual flood risk, provided that the community promised to adopt the necessary criteria when the study was completed. New structures could not obtain insurance until the final study, but were permitted to locate in the floodplain in ignorance of the true risk. This change, which later was called the Emergency Program, did expand the availability of insurance, but may have induced many unwise decisions for new construction. A positive change took place in December 1971 when the Federal Insurance Administration modified its regulations to require the 100-year flood be used as a minimum standard for the necessary Land Use Criteria. Prior to that time, it was suggested as a guide but not required. Along with that change, a limitation of a one-foot rise was established for the maximum impact of any future floodway criteria. The evolution of this criterion and the 100-year flood standard will be discussed further.

The chain of flood disasters in 1972 and 1973 under the voluntary program—Rapid City, South Dakota; Hurricane Agnes—caused flooding in Pennsylvania, Virginia, and New York; Buffalo Creek, West Virginia; and Mississippi River floods found thousands of uninsured flood victims, and federal outlays for these and other disasters were in the neighborhood of $5 billion. Confronted with the enormous loss of life in these disasters as well as spiraling federal costs for national recovery efforts, Congress passed the Flood Disaster Protection Act of 1973 (Public Law 93-234). This law put "teeth" into the Flood Insurance Program by requiring flood insurance as a condition for any federal or federally connected financial assistance in flood-prone areas. Significantly, the 1973 act also prohibited loans from conventional or public
sources for existing or proposed construction in identified flood-prone areas of communities that fail to adopt minimum floodplain management standards by certain deadlines.

The significance of this positive change in the direction of the program emerges in sharp relief when we consider that in January of 1970, only four communities were in the program; seven years later (1977) there were over 15,600 flood-prone communities that had adopted minimum floodplain management standards to gain eligibility for flood insurance and the long-sought federal financial assistance. At that time, about 97% of the structures in the nation's floodplains were eligible for coverage under the program.

At issue with the 1973 Act was the problem of administering the program with increased numbers, and the fact that the mandatory requirements brought many legal challenges and a demand for more specificity in the land use criteria, hydraulic and hydrologic procedures, and field surveys for mapping. In response to these problems, the Federal Insurance Administration proceeded to standardize its processes and revamp its regulations. These proposed changes were published in The Federal Register on January 21, March 26, and June 3, 1975. After all comments had been reviewed and evaluated, the final regulations were published on October 20, 1976.

E. O. 11988

The impact of the revised regulations were further enhanced in February of 1978 when the U. S. Water Resources Council published guidelines to federal agencies for the implementation of Executive Order 11988--Flood Plain Management Guidelines. The Guidelines required that all federal agencies use the floodplain standards established by the Federal Insurance Administration in preparing their procedures for compliance.

The new E. O. directed federal agencies to avoid floodplains unless it was the only practicable alternative. If it could not be avoided, the objectives of the National Flood Insurance Program would be used. For the first time, a set of standards was adopted for universal use by the federal agencies. This was a major breakthrough in "bureaucratic red tape" and gave the Federal Insurance Administration the national recognition it deserved.

Technical Issues

As stated previously, the National Flood Insurance Program affected all levels of government, often causing conflicts of standards and policies for regulation. The following is a brief history of the evolution of the more
critical technical standards that had to be accepted at all levels of government.

100-Year Flood

When the Congress created the NFIP, it mandated that flood hazard areas would be identified, but did not establish the definition of a "flood." Therefore, the Federal Insurance Administration, with the assistance of the University of Chicago, invited experts in the field to a national symposium in December of 1968. As chairman of the New England River Basins Commission Task Force on Flood Plain Management, I was invited to participate and was assigned to a committee to recommend hydrologic standards for the identification of flood-prone areas and their eventual regulation. Prior to the symposium, the federal agencies such as the Corps of Engineers, TVA, U.S. Geological Survey, SCS, and Weather Service had been using varying standards based on their individual assigned missions. Those standards varied from a 50-year flood (USGS) to a 10,000-year flood (TVA).

After extensive deliberation, the committee recommended that the 100-year flood would be a reasonable level to use in identifying flood-prone areas. It was considered to be large enough to identify a serious problem area which is normally beyond the imagination of most of the local people, but was not catastrophic and could readily be exceeded. There was insufficient time for an economic analysis, but the recommended level was a compromise that the committee members could support. It was a compromise between extreme values of flooding, but most important it was a compromise between an individual's right to develop his or her property and the public interest which must monitor the disaster assistance costs associated with those decisions.

The 100-year flood standard was accepted by the U.S. Senate Committee on Banking, Housing and Urban Affairs following hearings in 1973, and amended to the National Flood Insurance Act in 1974. The mandatory requirement of participation in the NFIP as a condition of federal financial assistance in identified flood hazard areas brought about many legal and technical challenges to the adopted standard. It has continued to have general acceptance and has proven economically prudent in most cases.

The economics of elevation versus the potential for damages or the high cost of insurance was demonstrated in the FIA publication, Elevated Residential Structures (1976). This conclusion was reinforced by the Corps of Engineers Hydrologic Engineering Center in its publication of 1978 entitled, Physical and
Economic Feasibility of Nonstructural Flood Plain Management Measures. The examples shown demonstrate that costs are exceeded by benefits for all locations, all flood hazard factors and all types of structures. Additional publications by FIA and FEMA--Floodproofing of Small Commercial Buildings (1979), Coastal Construction Manual (1981), and Elevating to Wave Crest Level (1981)--all provide expanded methods for determining the magnitude of costs and benefits which justify elevating to the 100-year level.

Floodways

The issues of floodway determination, selection, regulation, and management are complex and therefore the least understood at the local levels of government. These issues become much more critical when a community realizes that development can actually be denied if the proposed location falls within a "designated floodway." Thus the potential for litigation.

The floodway is a device to insure that once a 100-year flood elevation has been established for a riverine situation, subsequent development should not cause an increase in that level in a recurrence of the 100-year storm analyzed. It is effective by reserving a portion of a floodplain closest to the channel for general open space use. It assumes that the remainder of the floodplain can become fully developed and full encroachment on the valley cross-section will not result in an increase of more than one foot in elevation for a recurrence of the design storm. The one-foot rule is intended to be a maximum allowance in a compromise to permit development.

In terms of legal liability, it should be a "zero rise" so new development cannot encroach and make the problem worse. However, recognizing the state of the art of hydraulic computations, the one-foot allowance is reasonable assuming complete development in the entire cross-section of the floodway fringe areas, which is an extreme supposition. Studies by the Corps of Engineers have indicated that, on the average, full development of the flood fringe areas has resulted in 0.5 foot increase in water surface elevation. This lower elevation is due to the fact that floodway fringe development often includes street areas and open spaces between buildings that act as supplemental floodways parallel to the direction of the flow. It is recognized that in many small urban floodplains, any downstream modification which creates a backwater problem could be subject to litigation.

The FIA regulations do not address this issue except to say that a maximum of one foot is allowable. However, the selection of a floodway is not a FIA
decision, but a local planning decision constrained by FIA requirements. In the planning process, the impact of new development on existing properties must be a major consideration. The economic health of a community and the manner and direction of projected growth are all part of the normal planning process exclusive of flood-prone areas. Therefore, the floodway issue is an additional but very vital consideration. In an effort to minimize the possibility of future litigation due to adverse impact of development, many states have established standards more restrictive than FIA. These lower allowances which FIA has supported range from 0.2 to 0.5 feet.

The typical engineering analysis includes a procedure whereby both sides of a stream must be treated equally to avoid the charges of bias or discrimination in the planning decisions on permitting future development. An engineering solution that has been supported legally is called an "equal conveyance" method. This method, used by FIA and its contractors, attempts to establish lines of equal hydraulic efficiency, which is a function of the physical characteristics of the embankments, thereby removing any political bias. This generally results in the final floodway being centrally located in the floodplain where the greatest depths of flooding and velocities are located. However, there are other options for planning purposes where a meandering stream does not have a well-defined channel, or perhaps pressure for growth is taking place on one side of the river only. These require many alternate studies and considerations and must withstand legal challenges before FIA will accept other options. A "density floodway" concept is currently being considered to control encroachment by establishing the degree of development without establishing limits on location. This may have limited application, but may be the only equitable solution to those desiring to occupy the floodplain. The engineering and legal issues imply that it is complex but feasible.

Coastal Flooding

Most floodplain discussions center on river or watershed problems, yet a significant amount of annual flood damage is due to coastal flooding, normally the effect of wind-driven water associated with hurricanes, tropical storms, and "northeasters" in the Atlantic and Gulf areas. On the Pacific coast, there are severe storms. Flooding in large lakes may be a parallel situation. In the above situations, elevating and floodproofing structures in ways similar to those used in riverine areas are still valid solutions, provided the velocity of moving water is considered as an additional factor. The designation "V
zone" is a reminder of that additional hazard. In these areas the 100-year anticipated water level is also required.

The original published maps by FIA included a still-water level which reflected all of the dynamic forces except for the wind-generated waves. However, the insurance rates assigned to these areas were increased with a surcharge to reflect the potential of wave damage above the design level in a recurrence of the 100-year storm. In 1980, FIA revised its policy and required that the wave height effect be incorporated into the mandatory design level for coastal structures. These issues are still being debated. Technically both are good guidelines, with the inclusion of the wave height requiring more specificity with location and proximity of other development. In either case, they are intended to reflect a cost of occupancy in the coastal flood plain. This cost of occupancy has not been a deterrent to development often considered unwise in unstable coastal areas. In fact, the NFIP has been accused of encouraging this development which accelerates the instability of the coastal land forms.

Coastal Barrier Islands

These unstable areas are most prevalent in coastal barrier islands, which consist of unconsolidated material and are subjected to significant wind and wave energies. There has been much public debate over the last several years about the negative impact of the NFIP on these coastal barriers. This public outcry resulted in the Omnibus Budget Reconciliation Act of 1981 including a provision amending the National Flood Insurance Act as follows:

Section 1321(a) No new flood insurance coverage shall be provided under this title on or after October 1, 1983 for any new construction or substantial improvements of structures located on undeveloped coastal barriers which shall be designated by the Secretary of the Interior.

The impact of provisions of this legislation is difficult to project. It only addresses flood insurance and not the various federal programs which provide assistance to the development of the barriers infrastructure. Once the infrastructure is in place, the areas will develop even without flood insurance. Hopefully the communities will continue to enforce stringent building codes.

From the standpoint of the National Flood Insurance Program, the greatest significance of the Omnibus Budget Reconciliation Act of 1981 is that it is the
first instance where a decision has been made to deny insurance in a particular area. Denial of flood insurance is being used to deter and slow down development on undeveloped coastal barriers not simply due to the hazards but also to preserve fish and wildlife habitat and unique and valuable natural areas. This in itself represents a major change in direction and a conscious decision by Congress to use the NFIP to achieve goals beyond merely indemnifying property owners from flood losses and getting communities to adopt and enforce sound floodplain management regulation.

Shallow Flooding

There are other types of flood conditions unrelated to, or not readily associated with, channel flooding and flood profiles. These have been referred to collectively as "shallow flooding." These include flows over alluvial fans and over broad areas where channels or water courses are imperceptible, the direction of flow or overflow is often indeterminable, and/or variable reliable determinations of depth or extent of such flow by normal methods would be expensive and time-consuming. These have loosely and inconsistently been referred to as "sheet flow," "sheet flow flooding," and "sheet flooding," with different meanings in various regions.

Flooding characteristics and depth vary between the types of shallow flooding. Architectural and building practices vary with region of the country. These differences, along with the possibility of sheet erosion or increased velocities around corners of buildings, had to be considered in developing the necessary standards for damage reduction. The objectives are well defined, but the translation of those objectives into descriptive language for the regulations has been the most difficult part of the management.

Mudslides and Erosion

These two phenomena are being constantly debated as to their appropriateness in the NFIP. These are generally storm-related but their correlation with a specific meteorological condition is difficult to establish. Hence the controversy.

They are both the result of slope failure where soils became unstable from saturation or wind-driven water. In the case of mudslides in California, they have resulted in cases where loss in vegetation, due to a recent forest fire, left the slopes vulnerable to the onslaught of winter rains. The soils become unstable and slide, often burying structures with mud or carrying foundations and buildings away to destruction. The development of actuarial rates becomes
very difficult. FIA has relied very heavily on local governments and their experiences in developing the necessary management tools.

The problem of erosion is measurable over a period of time and therefore can be predicted. The question that FIA raises is: should the federal government provide a short-term role until the states involved develop management procedures to minimize losses? There have been several attempts to repeal this portion of the Flood Insurance Act, but the Great Lakes area representatives have resisted the change.

Community Compliance

When the NFIP was a voluntary program (1969-1973), community compliance was easily achieved. Communities that saw the advantages of the program were quick to provide the necessary documents and give assurances of enforcement. A simple annual report was sufficient.

When the program changed direction and made insurance mandatory as a condition of federal assistance in flood-prone areas, the FIA took on a "policing" role to monitor communities and establish suspension procedures and rights of appeal. The increase in number of communities made individual investigations an impossibility. Annual reports were formalized to be used as legal documents with "spot checking" by personnel when abuses were reported or witnessed.

Much of the abuse reported early in the program was due to lack of understanding by the local enforcement officials. In many rural communities, the elected or assigned officials had not had previous experience in this type of endeavor.

As discussed with reference to some of the earlier issues, this can be a complex program in some areas, and monitoring is more a problem of education and technical assistance than a policing effort. FIA has published many documents to provide this help and has initiated extensive research to simplify the procedures and requirements. The issuance of variances is the source of major abuses by local officials. FIA has tried to establish policies on this procedure, but there are legal limitations. Currently, the states are being considered as sources of talent to provide the necessary overview of the communities.

Role of the States

When the National Flood Insurance Program was enacted in 1968, the states were bypassed as an authority and the Federal Insurance Administration was
authorized to operate directly with communities. This created many problems, since the required land use regulations FIA was seeking from the community had to be authorized by the state. However, it may have been the Congress' opinion that the states had failed to enforce their "police powers," and thereby created the raid on the federal treasury.

In January of 1971, a quick survey was made of state land use control activities that would benefit communities wishing to participate in the NFIP. It was found that the states' involvement fell into five categories:

1) State establishment and enforcement of floodways, channel lines, and encroachment lines (California, Connecticut, Maryland, New Jersey).
2) State establishment of Flood Plain Regulation Standards; mandatory compliance within one year of data availability or state will enforce (Minnesota, Nebraska, Wisconsin).
3) State establishment of Flood Plain Standards; local adoption voluntary, but must meet standards. (California, Iowa, Kansas, Michigan; North Carolina pending).
4) State programs providing for assistance only; enabling legislation permitting local land use controls (Hawaii and Texas).
5) Enabling legislation only (most states).

Following this survey, inquiries were sent to all states inviting them to establish a role for themselves in the administration of the NFIP and indicate what standards they would recommend. In the absence of concrete responses, FIA adopted the 100-year standard and the floodway requirements previously discussed. At a later date, FIA did agree to recognize those states whose standards exceeded those published for the NFIP.

The publication of the regulations in October of 1976 put the states on notice that they had to establish procedures for controlling the location and design of state structures or structures built with state assistance. This required states to be responsible for their own actions in floodplains and brought them into line with local requirements and federal actions. Most states accomplished this by an executive order from the governor which was followed by individual agencies promulgating their own regulations and procedures to meet the requirement.

Program Assessment

The objective of the NFIP is to find ways to decrease loss potential while providing for the economic feasibility of continued and desired growth. Over-
restriction can be an economic waste, but under-regulation results in an unnecessary social cost. Individual decisions are still permitted provided they do not impose costs on others. The NFIP has all the features to carry out the above objectives.

Unfortunately, some of the amendments to the program have benefited special interests, and hampered the program from achieving its full national benefit. It appears that some in the Congress do not fully comprehend what its potential could be. The failure to provide funding to accelerate studies or permit more community assistance reflects this attitude.

Also preventing the program from achieving a greater impact have been the administrative decisions to reorganize assignments and staff for the responsible department within FIA or FEMA. In all these changes, floodplain management was relegated to a lower priority. However, that trend appears to be reversing. There were times that conflicts between the FPM regulations and the Insurance Agents Manual created serious problems in the field. With the current reorganization, those conflicts should be resolved soon.

The present mechanism for requiring insurance on federally assisted mortgages has many weaknesses, including poor monitoring. Some procedure should be found to establish the true costs of a potential disaster before a structure is built. This must include some vehicle for financial relief at the time of the disaster. Insurance appears to be the best mechanism to provide funding for a future need.

It should be understood that once a decision is made on building in a floodplain, the potential cost goes with that structure forever until a structural change is made. The decision makers should not be permitted to disregard those costs which the present loopholes allow. This is especially critical where variances from the required standards have been granted. If the decision to build in the floodplain includes a false sense of risk or financial hardship, the system should provide a mechanism of prepayment for flood insurance over the "useful life" of the structure. This cost would be a construction cost, no different than a cost for insulation or floodproofing. The cost would be included in the building or sale price and would not be separated from the other monthly costs of financing. With these prepaid costs identified, the decision to build in a flood-prone area versus flood-free areas would be made with all the facts at hand. Without this type of procedure, any variance granted would be ignoring the eventual public cost.
The "prepaid insurance" concept would satisfy the requirement that development did not create a greater demand on the federal treasury. The only monitoring required under that concept would be development in a floodway. The threat of litigation by upstream property owners should be sufficient to discourage major abuses in a floodway.
PART THREE
NATIONAL AND STATE ISSUES
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A PROPOSED STRATEGY FOR A
NATIONAL COASTAL DEVELOPMENT PLAN

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Maryland Water Resources Administration

Introduction

Our nation's coastal conservationists had high hopes for the Coastal Barriers Resources Act (CBRA) as a means to limit coastal development in a comprehensive manner. CBRA provides for wildlife habitat preservation and minimizing the wasteful expenditure of revenues by curtailing federal investment on identified undeveloped coastal barriers. However, eliminating federal financial incentives may not achieve the desired level of environmental protection and hazard mitigation that Congress intended for these vulnerable coastal areas. Although the CBRA states that: "A program of coordinated action by Federal, state, and local governments is critical to the more appropriate use and conservation of coastal barriers," such a program does not exist.

Our coast is a national resource that should be protected against excessive exploitation. The federal effort initiated by CBRA should be expanded through the establishment of a National Coastal Development Plan which is considerate of 1) developed and undeveloped barriers and adjacent mainland areas; 2) natural interdependent coastal processes and capacities; 3) state and local economies; and 4) the private investor. Such a National Coastal Development Plan would rely on a quota system, individual state participation, and voluntary plan enforcement.

The Coastal Barriers Resources Act

The Coastal Barriers Resources Act (CBRA) and the Department of Interior's report to Congress were important first steps in establishing a comprehensive federal policy for the nation's coastal barrier system. However, without additional cooperative federal and state incentives and disincentives, continued piecemeal development will continue on the nation's developed, partially developed, and undeveloped barrier resources.

CBRA and its accompanying studies provide an excellent basis for further-
ing national and state policies and initiatives which will:

1) Establish more specific guidelines for developing and conserving both
developed and undeveloped coastal resources,

2) Encourage cooperation among coastal states, and

3) Provide federal and state financial incentives for both barrier
resources and possibly non-barrier resource areas in coastal states
to make barriers less vulnerable to flood and ecological
catastrophes, and less of a liability to taxpayers through careful
coastal development and greater use of open space.

Despite its strengths, CBRA will not halt development of undeveloped
barriers, nor will it, in its present form, deal with the problems of developed
or semi-developed barriers. It is, at best, a "negative" planning act with a
relatively weak implementation mechanism as long as there is sufficient private
funding for new development. The interdependencies between developed and
undeveloped barriers have not been recognized by CBRA. Nor is there any effort
to balance development and conservation needs except by endorsing the status
quo.

Determining appropriate levels of additional development and redevelopment
for undeveloped, semi-developed, and developed barrier resources and guiding
public and private actions consistent with such levels will not be easy; how­
ever, more definitive procedures and implementing mechanisms are badly needed.
For starters the following could be considered for establishing such develop­
ment levels:

1) Health and safety considerations for individual barriers such as
   evacuation capacity during time of hurricane, ground water supplies,
   and sewage disposal capability,

2) Ecological considerations for not only the individual barriers but
   the entire regional barrier, estuarine, and marine system including
   wetlands, littoral zone, and dune systems,

3) Existing development on the entire system within the state, and
4) Economic considerations for the barrier system as a whole in the state and/or region including need for fishing ports, future residential development for tax base considerations, fuel exploration, etc.

From a federal and statewide perspective, the whole regional system must be considered in establishing policies for individual barriers. This will require inputs from all levels of government.

A Coastal Conservation Quota

In spite of the many problems in establishing quotas, such an approach is one of the few viable ways to consider when managing coastal growth. A Barrier Resources Coastal Conservation Quota could be established for each state which would reflect a variety of factors and inputs from all levels of government, and from social and scientific disciplines. A coastal conservation quota would be jointly established by the states and federal government and apply to developed, semi-developed, and undeveloped barrier resources. It would be implemented through a broad range of measures—not simply federal subsidies for the barriers themselves.

A quota system could reflect the realities and benefits of economic development as well as environmental protection. Based upon total barrier resource system acreage, barrier characteristics, and other factors, a development limit in the state might be set for each state with flexibility as to how this quota would be achieved (i.e., condominiums, industrial development). The incentives to develop barrier resources are much stronger than those incentives intended to protect these coastal areas.

This nation is not adverse to using quotas, standards, or funding in order to achieve social changes. However, such mechanisms have been called various things and generally depend upon voluntary state and/or local participation and cooperation. Consider the 55-mile-an-hour national speed limit. States have voluntarily set the maximum speed limit at 55 miles per hour on all state and county road systems, and must demonstrate that they are properly enforcing the speed limit. States may increase the limit within their jurisdiction, but they will most certainly lose federal transportation funds. In any event, the speed limit program remains voluntary. The same may be said for certain affirmative action programs.

The Coastal Conservation Quota system suggested here would be voluntary. States which chose to participate and conserve a good portion of their coast
would be compensated for the loss in revenue in other areas of the state through federal funding. Those states which decide to exploit the coast to the maximum extent in order to increase state and local revenues would suffer a decrease in general federal funding.

A Prototype

The tax and economic development benefits of barrier resource development have not been adequately considered by previous coastal zone management efforts. During the last decade (without major storms), many developed barrier communities have been contributing significantly to the National Flood Insurance pool, state property taxes, and other taxes.

Over the past twelve years, the Town of Ocean City in Maryland has paid a conservatively estimated $3.7 million in flood insurance premiums. Since 1978, $187,589 has been paid in claims to Ocean City residents. Ocean City has been a moneymaker for the Federal Insurance Administration and the State of Maryland, although this may not continue when a major northeaster or hurricane strikes the area. Economically speaking, Ocean City is the third most important city in the state. The 5.5 square-mile area which comprises Ocean City supports an assessable base of over $5 billion dollars, which is third only to the City of Rockville and Baltimore City--both physically larger cities. Other revenues generated by Ocean City are equally impressive to the point that the state of Maryland would realize a significant economic blow if the island development were not there. In other words, it behooves the state to contribute to shore erosion protection measures and assist with the rebuilding after an Ocean City disaster simply to protect the state economy. Compared to other areas in Maryland, state and federal aid to the Ocean City area is next to nothing.

Another interesting aspect of Maryland is that all of the state's coastal barrier development is concentrated within a 5.5 square-mile area. The remaining portion of the 30-mile coast is total open space, state and federal park land. The infrastructure serving the Ocean City area is concentrated along two main accesses and in the immediate island and back bay area.

The state of Maryland has informally established a de facto conservation quota of approximately 80% of its total barrier resources system. This conservation quota was made possible only through prudent state and federal acquisition and management programs years ago. Such massive public funds are no longer available for acquisition purposes. Therefore, other states would need
a companion policy to CBRA, relying on regulation and financial incentives to achieve the purposes of minimizing loss of life, curtailing wasteful expenditures of federal revenues, and mitigating damages to coastal natural resources.

**Plan Implementation**

In coastal states, barrier resources are often viewed as a valuable commodity similar to oil, natural gas, and minerals. It is not inconsistent with established state resource policies to set limits on exploitation of such resources. Assuming that adequate criteria and a federal/state process were developed for establishing conservation and development quotas, how would such quotas be implemented? Three steps might be followed.

First, a coastal conservation quota would be established for each state. Such a quota would consider the natural capacity of the barrier system to support development, acreage in the system, the value of the environmental resources on the barriers, economic development potential, and the level of development which could be tolerated before the barrier resource becomes a financial liability to the state. High-density development on smaller islands might be less of a liability than low-density development on larger islands because of the extra miles of infrastructure and expense of evacuation. In some cases, it may be best to encourage high-density development in specific areas in order to leave remaining barriers free of development. For development areas, it may be preferable to choose a section of the barrier on which all environmental concerns would be secondary to development concerns, and to allow for optimum density with the condition that no other section of the barrier would be disturbed.

Second, a Coastal Development Plan would be developed for each state. Federal agencies would assist states and local communities with the development and implementation of such a plan. Similar to the assistance provided under the National Flood Insurance Program and the Coastal Zone Management Act, federal and state agencies would cooperate technically and financially in the planning process consistent with the conservation quota.

Third, all federal financial assistance appropriated for each coastal county with barrier resources would be conditional upon proper implementation of the Coastal Development Plan. For example, if the City of Wilmington applied for federal urban renewal funds, a clearing house system similar to E.O. 11988 could reveal whether coastal conservation measures were in order,
and funds would be distributed only after a satisfactory finding.

It is also suggested that perhaps non-coastal federal financial assistance and flood insurance should be conditioned upon each state and local government's proper management of its coastal barriers. It is taking CBRA considerably farther and making the entire state dependent upon prudent use of the coast.
GREENHOUSE EFFECT AND SEA LEVEL RISE

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Introduction

Most of our discussions and policies address flood losses as acts of God. There is a certain probability that the forces of nature will combine to create a flood from a storm surge or rainfall. Because we cannot predict where or when the next major storm will strike, we tell everyone in a certain area that there is a certain probability that a storm will strike them, and we ask them to plan accordingly. Although there are some notable examples of people disregarding the risk of a serious storm, policies have moved a long way toward addressing the risk of flood losses.

The papers by Groat, Gagliano, Edmonson, Pilkey, and others in this volume address a different aspect of the problem: the loss of land. Even though the loss of land is more predictable than the occurrence of a storm, our flood prevention policies often ignore the future increase in flood damages resulting from this factor. In Louisiana, for example, where the loss of 50 square miles per year will almost certainly make many developed areas extremely vulnerable in the next 30-40 years, no one has even estimated the flood claims that can be expected in the year 2015 if present trends continue.

In the coming decades, most of the U.S. coast may be experiencing rates of land loss similar to the current Louisiana situation. Increasing concentrations of carbon dioxide and other gases are expected to cause a global warming that could raise sea level several feet in the next century and one foot in the next 30-40 years. This paper discusses the basis for expecting a rise in sea level and the implications for strategies to prevent land loss in Louisiana.¹

Sea Level Rise and the Greenhouse Effect

A planet's temperature is determined primarily by the amount of sunlight it receives, the amount of sunlight it reflects, and the extent to which its atmosphere retains heat. When sunlight strikes the earth, it warms the surface, which then radiates the heat as infrared radiation. However, water vapor, carbon dioxide, methane, chlorofluorocarbons and other gases in the atmosphere absorb some of the energy rather than allowing it to pass undeterred through the atmosphere to space. Because the atmosphere traps heat and warms the earth in a manner somewhat analogous to the glass panels of a greenhouse, this phenomenon is generally known as the "greenhouse effect."

Since the industrial revolution, the combustion of fossil fuels, deforestation, and cement manufacture have released enough CO₂ into the atmosphere to raise the atmospheric concentration of carbon dioxide by 20 percent (Hoffman, 1984). Energy experts generally expect the concentration of CO₂ to double in the latter half of the 21st century, and the concentration of all greenhouse gases is expected to double by 2050, perhaps sooner. Because the extent to which these gases absorb infrared radiation is well-established, Hansen et al. (1984) calculate that a doubling would directly raise the earth's average temperature 1.2°C if nothing else changed, an estimate that is universally accepted by physicists and climatologists.

The direct effect of the doubling of greenhouse gases would most likely be amplified, however, because of the effect on other climatic factors. For example, a warmer atmosphere would retain more water vapor, also a greenhouse gas, and snow and floating ice would retreat, decreasing the extent to which sunlight is reflected into space, thus causing an additional warming. After evaluating all of the evidence, two National Academy of Sciences (NAS) panels concluded that the eventual warming from a doubling of greenhouse gases would be 1.5 to 4.5°C (3-8°F) (Hoffman, Keyes, and Titus, 1983).

A global warming of a few degrees and the resulting expansion of sea water could be expected to raise sea level by one-half meter in the next century. Mountain glaciers, which have retreated in the last century, could melt and
release enough water to raise sea level 12 centimeters (5 inches) (Revelle, 1983). Antarctica could contribute to sea level rise either by meltwater running off or by deglaciation (ice discharge); however a complete deglaciation of the west antarctic ice sheet would take several centuries (Bentley, 1983; Hughes, 1983). Revelle estimates that a 3°C warming could cause Greenland's glaciers to melt enough water to raise the sea another 12 centimeters in the next century and that the combined impact of thermal expansion and melting of Greenland and mountain glaciers could raise sea level 70 centimeters (2 and 1/3 feet) in the next century (Revelle, 1983). Although Revelle stated that Antarctica could contribute two meters per century to sea level starting around 2050, he declined to add this contribution to his estimate.

In a report by the U.S. Environmental Protection Agency (EPA) entitled Projecting Future Sea Level Rise, Hoffman, Keyes, and Titus (1983) stated that the uncertainties regarding the factors that could influence sea level are so numerous that a single estimate of future sea level rise is not possible. Instead, they consulted the literature to specify high, medium, and low estimates to account for all of the major uncertainties, including fossil fuel use; the portion of carbon dioxide that remains in the atmosphere; future emissions of trace gases; the global warming that would result from a doubling of greenhouse gases (the NAS estimate of 1.5-4.5°C); the diffusion of heat into the oceans; and the impact of ice and snow. Figure 1 illustrates the EPA and NAS estimates.

Implications for Louisiana

A rise in sea level from the greenhouse effect would accelerate the loss of wetlands that Louisiana is experiencing today. Marsh drowning and saltwater intrusion would both increase. The required time for Terrebonne Parish to convert to open water, for example, would be reduced from 100 to 60-75 years, if no action is taken. The local government there has developed a 25-year construction plan to help restore natural processes and curtail wetland loss. Given the long lead time necessary for gaining a public consensus on the public works that may have to be built or modified, decisions that local officials might like to delay until 2020 will probably be necessary within the next ten years.
One of the most important problems concerning the greenhouse effect is our inability to forecast future sea level rise accurately. Although much of the nation has the luxury of being able to wait 20 years until better forecasts are available, Louisiana cannot wait that long. Thus, it is very likely that we will have to develop a wetland protection strategy that addresses the possibility of a "greenhouse" rise in sea level before we know what its magnitude will actually be. Nevertheless, the sooner we have better forecasts of sea level rise, the sooner Louisiana will be able develop strategies that address an accurate understanding of what lies ahead.
The most fundamental threat to any government is the possibility that its land will be taken away. In response to current trends, local governments and the State of Louisiana have initiated a level of effort unprecedented in the history of environmental protection. The Louisiana Legislature created a $35 million Coastal Protection Trust Fund to research, develop, and demonstrate methods to slow coastal erosion. Local governments have also appropriated millions of dollars and have been joined by private landowners such as Texaco and Tenneco LaTerre. Terrebonne Parish has initiated a public awareness campaign that includes billboards, pamphlets, slide shows, and its secondary school curriculum (Edmonson, this volume).

Although there are many uncertainties surrounding the issue of future sea level rise, we feel that two recommendations are appropriate. First, the state must take a more active role to ensure that the research necessary to accurately forecast sea level rise is undertaken in a timely manner. If coastal interests ignore the issue of future sea level rise until conclusive predictions are available, the predictions may never become available; the substantial increase in basic research that is necessary will not take place until the people who need the information start to make that need clear.

Secondly, the state must recognize that it will probably have to make major decisions before the verdict is in, even if an acceleration in research does take place. We will probably not have accurate forecasts of future sea level rise before 1995; action to address land loss will be necessary before then. In the meantime, it would be very unwise to assume that a rise in sea level will not take place. Instead, our policies should be based on the fact that we do not know what will happen. This will require assessing the consequences of particular actions if the sea does rise and if it does not.

It would be nice if we could ignore this issue until it is proven, but certainty is not always possible. Like financial markets, we should follow the principle of using all available information and treat sea level rise as a risk to be recognized. The fact that the future is unknown does not mean that we cannot have confidence in policies that leave us better prepared for what could happen.
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SEA LEVEL RISE AND SUBSIDENCE IN COASTAL LOUISIANA

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Introduction

The major impact of relative sea level (RSL) in Louisiana is: 1) land loss within the wetlands and marshes and 2) erosion of beaches and barrier islands along the shoreline. However, the exact role sea level rise plays in the nature and severity of land loss and coastal erosion remains unresolved. This question is most important to wetland managers and coastal planners in assessing the future existence of southern Louisiana's coastal zone.

A number of depositional environments are represented within the 26 million sq. km of coastal wetlands in southern Louisiana. The most common environments are the coastal marshes which account for 40% of all coastal wetlands in the United States (Gosselink, 1980; Davis, 1983). The coastal wetlands are flat, low lying areas with average elevations of less than 1 m and are being converted to open water bays or lagoons at a progressive geometric rate exceeding 101 sq. km per year (Gagliano et al., 1981). Louisiana faces the most critical barrier shoreline erosion problem in the United States due to relative sea level rise upon which storms and man's activities are superimposed accelerating the problem (Penland and Boyd 1982).

Data Analysis

Eighty-one tide gauge stations, maintained by the Army Corp of Engineers (ACE) and National Oceanic and Atmospheric Administration (NOAA) (Fig. 1), and several kilometers of historical leveling data have been analyzed in this study for the purpose of determining the history of recent sea level rise in coastal Louisiana. Yearly means have been calculated for 20 tidal stations with continuous records from
Figure 1. Location of tide gauge stations in coastal Louisiana examined in this study.

Figure 2. State-wide yearly means from 1942-82 for 20(N) tide gauge stations.

**YEARLY MEANS 1942-1982**

\[
\text{.52} \pm .08 \text{cm/yr}
\]

\[N=20\]
1942-82, and display a sea level rise rate of $0.52 \pm 0.08$ cm/yr (Fig. 2). This rate is 2.26 times greater than the assumed Gulf of Mexico eustatic sea level rate ($0.23 \pm 0.03$ cm/yr at Pensacola, Florida) and 3.47 times greater than the assumed world-wide eustatic rate. There is no consensus as to a world-wide eustatic rate, but an average rate is estimated at 1.5 mm/yr (Hicks, 1978; Gornitz et al, 1982; Barnett, 1983).

Tide gauge measurements at 20 localities across the Louisiana coastal zone were plotted relative to mean sea level against the period of record. A computer-generated linear regression was calculated to determine a rate of rise for each tide gauge station (Fig. 2). In order to compare the tidal data, it was necessary to divide the 20 stations with continuous record into two 20-year epochs (1942-62 and 1962-82) to encompass the 18.9 year lunar orbital cycle. River stations were avoided and anomalies in the data were corrected to adjust for major storm impacts and flooding. From these analyses, temporal differences and rise rates were determined for seven physiographic regions in the coastal zone. These regions each possess a unique set of geologic process, sedimentation rates, drainage patterns and depositional histories. Subsidence rates are determined by analysis of geodetic leveling profiles and assuming subsidence is the only significant remaining component accounting for RSL rise after deleting the eustatic component in that area.

**Results**

Figures 3A,B depict the rates of rise from 1942-62 and 1962-82. The first 20 year epoch shows a rise of $0.11 \pm 0.20$ cm/yr, whereas, the second 20-year epoch reflects a rise of $0.91 \pm 0.23$ cm/yr, approximately nine-times greater rate of rise. Regional variation in sea level rise is shown in Figures 4A,B for 1942-62 and 5A,B for 1962-82. Regions II and V show the greatest increase in water level rise between the two epochs, with Region VII being the least variable.

Grand Isle, located in Region IV, is the reference station to which the leveling datum is based (Fig. 6). Grand Isle was arbitrarily chosen since it contained a tidal station which is maintained by NOAA and can be compared easily to the Pensacola, Florida station. Assuming compactional subsidence at Grand Isle by comparison to Pensacola is 1.03 cm/yr, the rates of subsidence decrease markedly as one moves
Figure 3. A) Graph of sea level rise for 1942-62. B) Graph of sea level rise for 1962-82.

A)

YEARMY MEANS 1942-1962

B)

YEARMY MEANS 1962-1982

Figure 4. A) Regional summary showing water level rise from 1942-62. B) Histogram of water level rise from 1942-62 by physiographic regions.
Figure 5. A) Regional summary showing water level rise from 1962-82. B) Histogram of water level rise from 1962-82 by physiographic regions.

A REGIONAL SUMMARY (1962-82)

I Chincote Plain
II Archaic Basin/ Vermilion Bay
III Lafourche Delta
IV Barataria Bay
V Belize Delta
VI St. Bernard Delta
VII Pontchartrain Area

Louisiana Geological Survey

Figure 6. Location of leveling datum lines used in this study to compute subsidence rates.

KEY
- TIDE GAUGE STATION
- LEVEL LINE
landward. One hundred twenty km away from the coast, the rates of subsidence are only 0.001 cm/yr (Fig. 7A, B).

Discussion and Conclusions

The following observations can be made from the analysis of tidal and leveling datum in the Gulf Coast of Louisiana. First, leveling data shows that subsidence is greater along the coast with a marked decrease landward. Second, there is a significant increase in water-level rise between the two 20-year epochs from 1942-62 and 1962-82 (Fig. 4B and 5B). Possible reasons for the spatial and temporal differences could be due to the amount of flooding, channelization and diversion of streams and rivers, increase in dredging, and decreasing rates of sedimentation. Temporal variations could also be due to variation in eustatic rise during that time period.

Accelerating RSL can have several effects on the Louisiana Coast including shoreline erosion, barrier island breaching due to storm impacts, salt water intrusion, marsh deterioration, flooding, and land loss. Comparing the regions of greater water-level rise to regions of highest land loss there does not appear to be a one-to-one relationship. Areas of greater amount of land loss. This suggests that sea-level rise contributes to land loss but is not the only causal factor.

Figure 7. A) Plot of leveling datum along a profile line from Grand Isle to Raceland, Louisiana for 1965 and 1982. B) Summary plot showing vertical elevation change from 1965-1982.
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Acknowledgements

This study was conducted as part of a regional investigation of statewide trends in subsidence, land loss and sea level rise in coastal Louisiana. Funding for this study was provided by the Act 41 Coastal Environmental Protection Trust Fund through the Louisiana Geological Survey and also by the Terrebonne Consolidated Government (LSU Contract No. 137-50-4108). Karen Westphal and Carol Terry are acknowledged for their cartographic skills. Laree Lejune and Robin Sanders helped compile the summaries of historical tide gauge and leveling data and were invaluable to the completion of this study.
LOCAL GOVERNMENT INVOLVEMENT IN COASTAL PROJECTS' FLOOD HAZARD REDUCTION

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Introduction

Although Terrebonne Parish lies near the terminus of North America's largest river system, its flood problems are caused by coastal deltaic processes. The channelization of the Mississippi River has contributed to the accelerated destruction of the deltaic plain. The combined influences of subsidence, sea level rise, and erosion have forced the Parish to address two types of flood hazard reduction: protection of homes, businesses and infrastructure; and protection of estuarine habitats. Regional flood hazards include tidal, backwater, and runoff flooding, and saltwater intrusion. To protect itself, the Parish has adopted a multi-faceted floodplain management program. Program activities include research, public education, construction, and management.

The lack of a state-implemented coastal management and protection program has made the Parish realize it has to undertake the management of its barrier islands and wetlands itself. We further understand that these management plans need to go beyond the land use regulatory nature of CZM to a long-range, capital-intensive maintenance and construction program.

Identification of the Problem

The disruptions in the natural cycles of Louisiana's deltaic plain have produced extreme land loss problems for Terrebonne Parish. Over a 23-year period from 1955-1978, it was documented that Terrebonne Parish lost 15% of its land area and 42% of its barrier islands to subsidence, erosion, and sea level rise (Wicker, et al., 1980). At these rates it is calculated that all of Terrebonne's erodible land will be gone in 98 years.

As erosional forces continue unchecked, flood hazard reduction measures become increasingly important not only for the protection of infrastructure, but also for the protection of valuable estuarine habitats. As the sea continues to encroach upon the mainland, natural drainage patterns are affected as
gradients are reduced. Reduced gradients, tides, and winds cause extreme backwater flooding problems in many areas of the Parish. Rainfall in excess of 65" per year compounds this problem. The interdistributary basin floods first, followed by the back side of the natural levee ridge. Bayous receive very little natural runoff.

With the continual breakup of the barrier islands and marsh ecosystems, saltwater travels further northward during tropical storms and southerly winds, further feeding the cycle of land loss, erosion and flooding. Saltwater intrusion, flooding, land loss, subsidence, and sea level rise are interrelated. When the people of Terrebonne Parish recognized this fact, we determined the only long-term solution was to manage the total ecosystem including the barrier islands and the wetlands. If the Parish can stabilize its land loss problem, it will be able to lessen salt water intrusion and flooding.

**Program Goals**

After identifying its problems, Terrebonne Parish developed goals to address the identified problems:

1) To develop additional facts about the barrier islands and our marshes.
2) To draw public attention to the problems associated with barrier island and marsh deterioration.
3) To develop and implement programs and plans for the preservation and protection of Terrebonne's estuary.
4) To reduce the scope of damage to the barrier islands through physical change.

**Comprehensive Data Base**

In the mid 1970s, the Parish recognized that it had little information on the subjects of shore erosion, subsidence, drainage, marsh preservation, and restoration of its barrier islands. As a result, several habitat and barrier island studies were conducted. The Parish is currently continuing the following studies to develop additional facts about its barrier islands and marshes:

1) **Sand Resource Inventory**
   The gulf bottom around the coastline is being investigated to locate sand resources for our barrier islands.
2) **Marsh Valuation Study**
   A study is being conducted to develop economic valuations of Terrebonne Parish wetlands for input into the Corps' present studies and benefit/cost ratio procedures.

3) **Oyster Contamination Study**
   The oyster contamination study deals primarily with the question of the sources of sewerage or fecal contamination, and the methods used by health authorities in monitoring for fecal contamination.

4) **Subsidence Study**
   The subsidence study will classify the marsh and ridge lands as either stable, erodible, or accretional, and will aid the Parish with management and development decisions.

5) **FEMA Appeal**
   An appeal of FEMA's information base and methods for calculating FIRM projects is in process.

6) **Sea Level Rise Study**
   Marsh protection strategies will be analyzed against sea level rise scenarios in an anticipated upcoming study.

7) **Master Drainage Plan**
   A comprehensive parish-wide drainage plan is being prepared.

8) **Potable Water Supply Plan**
   To determine the long-range (20 years) potable water supplies and distribution requirements, the Parish has prepared an engineering economic feasibility and capital improvement program.

**Public Education**

Last year Terrebonne Parish began a public education campaign in recognition of the fact that it would need full public cooperation and support in order to combat all its problems with coastal erosion, land subsidence, sea level rise, saltwater intrusion, and flooding. The education program has a
number of facets:

1) **Slide Presentations**--Recently, the Parish produced two slide shows on the environment and the economy.

2) **Handouts**--To supplement the slide shows, three brochures were developed for distribution to the general public and the school students.

3) **Posters**--To convey the importance of preserving our barrier islands and wetlands, a set of posters was designed and printed.

4) **Barrier Island Foundation**--A foundation has been formed to encourage and support the continuation of efforts to preserve and protect the Parish and its inheritance.

5) **School Programs**--The Parish government and the school board developed and implemented an eighth grade curriculum dealing with geology, erosional problems, utilization of renewable and non-renewable resources, and solutions.

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**Wetland Preservation**

Terrebonne Parish has recognized that its wetlands have immense monetary and aesthetic value. Presently, Terrebonne’s estuary produces over $30 million per year in seafood and recreational income alone. The Parish is unwilling to abandon its wetlands to the forces of nature. Therefore, plans and programs are now being generated and/or implemented by both the public and private sectors. Included in these programs is the maintenance of, and hazard mitigation in, over 1,600 acres of wetlands within our present forced drainage system. The Parish is also preparing to construct salt water barriers to protect the interdistributary basins. These levees will follow water courses such as Bush Canal, Falgout Canal, and Lake Boudreaux. Water control structures will also be installed at critical locations to control flooding and manage habitats.

The overall scheme of wetland protection and flood hazard reduction incorporates several rings of protection levees: one at the wetland-nonwetland interface to protect infrastructure (present force drainage system), and one at the wetland-gulf water interface to protect the estuary (proposed).
Barrier Island Preservation

Terrebonne's barrier islands are its first line of defense against attacks from the sea. If these islands are lost, it is predicted that Terrebonne's land loss will accelerate geometrically, and increased flooding will follow. The state of deterioration on the barrier islands of Terrebonne Parish is quite dramatic. Specific erosion rates for the Isles Dernieres chain over a 25-year period have been estimated at 33% of its total land area. Shoreline erosion rates average 34' per year (Wicker et al., 1980).

Despite the various physical processes that are contributing to the loss of the barrier islands, remedial measures can be taken to retard them. Terrebonne Parish was the first to reconstruct 35 acres of barrier island in the state of Louisiana. Our nonstructural/flexible structural approach will allow the islands to migrate. Eventually, the island will migrate northward and abut the proposed levee, adding further toe protection. It is important to keep the overall integrity of the islands intact as they migrate. This does not require massive dune construction measures.

Conclusion

Terrebonne is fortunate that the extent of erosion caused by severe storms has been minimal over the past several years, and that it has not been subjected to the erosion forces of a major hurricane. However, if existing processes continue unchecked, all of Terrebonne's wetlands will be gone in 75 years. With the loss of the islands and the estuary, Terrebonne, Louisiana, and the nation will lose billions of dollars in renewable resources and recreational industries. In addition, the increased cost of hurricane and flood protection will become staggering for the Terrebonne-Lafourche Metro area.

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FLOOD INSURANCE STUDY REVISIONS: BLESSING OR CURSE?

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Dewberry & Davis

Introduction

This paper examines the Federal Emergency Management Agency's (FEMA) current processes for maintaining the accuracy and usability of a community's Flood Insurance Study. The paper is written from the perspective of a contractor to FEMA and, as such, carries no endorsement by FEMA.

Background

FEMA's current study effort is directed toward reaching the Congressionally mandated goal of converting all flood-prone communities to the Regular Phase of participation in the National Flood Insurance Program. As the number of communities entering this phase increases, FEMA's efforts will logically shift to maintenance, that is, keeping the Flood Insurance Studies up to date.

Two alternatives are available to FEMA to update a community's Flood Insurance Study: 1) Hire a contractor to generate new information and produce a restudy; or 2) Revise the Flood Insurance Study via a map revision or map amendment based on community-supplied information.

It is unlikely that a restudy program will ever receive as intensive a commitment of money and resources as has FEMA's current study effort. While it once may have been envisioned that communities would be restudied every five years, this kind of comprehensive maintenance program will be impossible under FEMA's current fiscal constraints. Therefore, in order to achieve a maintenance program of any value, FEMA must seek community support in sharing the responsibility for keeping studies up to date.
In order to define the applications of the revision and restudy processes, the reasons why a Flood Insurance Study becomes outdated must be examined. The hydrologic and hydraulic impacts of development are by far the most common contributors to making a Flood Insurance Study, or portions of it, obsolete. Channel modifications, fill, and the construction of dams, levees, berms, bridges, and culverts affect the validity of Flood Insurance Study analyses. Projects of these types are sometimes built to protect existing development; however, they are most often constructed to allow for new development.

The potential for development in a given area is another factor contributing to the need for Flood Insurance Study revisions. Non-construction-generated revision requests may stem from the potential for development in a flood plain. For example, requestors submitting a new hydraulic analysis for a stream are often motivated to do so because they have new development plans that would be facilitated by the new analysis.

Two of FEMA's goals are to supply communities with the most accurate, up-to-date Flood Insurance Studies possible and to maintain the accuracy of these Flood Insurance Studies over time, thereby providing the communities with the best bases for making sound flood plain management decisions. The restudy process, which is currently applied only to the most out-of-date Flood Insurance Studies, does not keep up with development. It is more a means of catching up, rather than staying ahead. Therefore, communities face a Catch-22 situation: development causes a Flood Insurance Study to become outdated, but they need an up-to-date Flood Insurance Study to monitor the impacts of development. Thus, a periodic restudy plan is not appropriate for most maintenance purposes. However, predicated on updating a study with community-supplied information, the revision process can be an effective means of keeping Flood Insurance Studies up to date. Clearly, it's a blessing!

Communities' and States' Roles in the Study Maintenance Effort

Communities must recognize that for the revision/amendment approach to Flood insurance Study maintenance to succeed, they must assume the responsibility of supplying FEMA with the new information. The responsible communities must then learn
what type of information FEMA requires and what FEMA can accomplish toward study maintenance with that information.

The distinction should be made between map revisions and map amendments. Map amendments were originally designed to remove structures that, due to graphical limitations, were inadvertently included in the Special Flood Hazard Area from that designation. To obtain a Letter of Map Amendment, an appellant must prove that his structure is above the base flood elevation by submitting survey or other topographic information to FEMA. Letters of Map Amendment have also been granted conditionally; that is, a proposed structure as located on a grading plan could obtain a determination that it would be above the base flood elevation if constructed as proposed. The process has been corrupted over the years in that conditional Letters of Map Amendment have been granted for structures proposed to be elevated above the base flood elevation on fill. This practice will probably be discontinued in the future.

Map revisions are needed if any change in the base flood elevation is involved. All of the construction-related flood plain modifications mentioned earlier, as well as the non-construction-related development of new hydrologic or hydraulic analyses, fall under the scope of map revisions. Map revisions are also granted conditionally, by FEMA stating that if a project were constructed as designed, it would be cause for a map revision. These conditional Letters of Map Revision, or "belief letters," are often needed by developers to obtain financing, construction permits, or buyers.

State flood plain managers can assist communities in working with FEMA in two general areas: education and coordination.

Education

The appropriate State agency should be familiar with FEMA processes and requirements for revisions and amendments to flood insurance maps. FEMA has published several documents that detail the steps necessary to obtain a revision or amendment. These documents are termed Conditions and Criteria and cover Map Revisions, Floodway Revisions, and Letters of Map Amendment; the State agency should have a supply of these available for distribution. FEMA spends a substantial amount of time and effort responding to and educating individuals who are not aware of the revision/amendment policies; these citizens realize that they need help too late, when they are unable to obtain financing or various permits. FEMA's map revision and amendment policies and procedures should be presented by the States to communities during visits. If, as with some States, representatives of the State Coordinator's office
attend the final community Consultation and Coordination Officer's meeting, where the Flood Insurance Study is presented to community members, the revision process could be brought up at that point, thereby arming citizens with the program knowledge they need to maintain a useful Flood Insurance Study before the fact. Of course, "monitoring visits" to communities already participating in the Regular Phase of the program would be appropriate occasions to discuss study maintenance.

Another area of responsibility the States can assume is to develop the role of the State repository. Under current revision procedures, it is essential that any new analyses be based on those in the original study. The original study data should be catalogued and stored such that it is easy to locate and distribute. If facilities or funding limit the State's ability to maintain the data, the State should work with individual communities in developing well-inventoried, accessible repositories in a uniform manner.

There are many coordination efforts that the States can undertake to help communities keep their Flood Insurance Studies up to date and thus more usable. For example, they can coordinate, to the extent possible, with other State or non-FEMA Federal projects that will ultimately affect a community's Flood Insurance Study. States should encourage the development of information that would lend itself to a study revision. For example, many bridge replacements and channel modifications carried out by a State highway department will result in a change to the water-surface elevations and/or flood boundary and floodway delineations. Many of these projects (especially the replacement of an undersized bridge or culvert) will result in a reduction in flood hazards. A community will then request that its study be revised to reflect the change. If the data from the original study has been utilized by the highway department in the design phase of the project, and if any hydraulic analyses are performed so that they are compatible with the existing study, a map revision can most easily be accomplished by FEMA.

In keeping with a general National Flood Insurance Program principle, State agencies can also encourage the use of information presented in map revisions, conditional Letters of Map Revision, and conditional Letters of Map Amendment as minimum criteria. Communities should be aware that data and analyses have been reviewed with FEMA minimum criteria in mind and, as such, it is their prerogative to be conservative in the application of FEMA's findings. For example, in a rapidly developing
area, perhaps channel modifications or other structural measures should be designed with future conditions or ultimate development discharges, even though FEMA, for purposes of a conditional Letter of Map Revision, compares the design to existing Flood Insurance Study data. Likewise, while FEMA could grant a conditional Letter of Map Amendment for structures proposed to be built at or above the base flood elevation, perhaps community requirements to build one or even two feet above the base flood elevation would be more prudent.

Observations on and Expected Changes to the Study Maintenance Effort

Revisions can effectively put off the pressure or need for a restudy of a community's flood hazard. It is entirely feasible that revisions can be effective in keeping a community's Flood Insurance Study up to date. Factors that help determine the effectiveness of the revisions process include:

- the amount and rate of development
- the accuracy of the effective Flood Insurance Study analyses
- community awareness and monitoring of development in flood plains
- development of information/analyses documenting the flood plain changes.

Another related aspect of the revisions process is the fact that for the process to be at all successful, it inherently involves the community. This is not to say that revisions are the only way of involving communities in floodplain management, but they do lead to the community's being more aware of what is happening in its flood plains and the resultant impacts of development. Finally, revisions can save FEMA money, since the data is usually provided by the requestor. The information must still be reviewed and mapped as necessary.

The revision/amendment processes do have their criticisms. One is the patchwork nature ("band-aid approach") of updating a community's Flood Insurance Study. It is essential, though sometimes very difficult, to determine if the cumulative impacts of development are being properly considered. This is especially important in the rapidly growing communities with multiple revision requests.

Revision requests, particularly those involving proposed projects, also tend to draw FEMA into regulating a community's floodplain development. As mentioned earlier, many things can hinge on FEMA's "verdict," including construction permits,
financing, and large amounts of money in general. FEMA's conditional determinations are often used by developers as leverage with the community: "The Federal government endorses my plans; you have to grant me my construction permit." FEMA is also drawn into providing "free" engineering (at the taxpayers' expense) for reviewing design concepts, as opposed to a developer's final design that has the community's endorsement.

As a result of the experience FEMA has gained by processing an increasing number of revision requests each year, several changes in their philosophy toward current maintenance systems can be anticipated. For example, Letters of Map Amendment will probably be granted only for structures inadvertently included in Special Flood Hazard Areas; projects based on elevating structures on fill would be handled as map revision requests.

FEMA recently published a proposed rule on adopting a reimbursement procedure for conditional determinations. Through this procedure, FEMA hopes to recover much of the cost associated with the review and processing of conditionals by billing the requestor. It would follow that knowing they will be charged for this, whether they get a favorable response or not, requestors will put together a better submittal. Ideally, the request would come through the community, with their endorsement and certification that the project is compatible with their flood plain management objectives. The experience gained with revisions based on community-supplied information may also be evidenced in FEMA's restudy philosophy. It is safe to assume that FEMA will be working more and more closely with communities, keeping their needs and resources in mind. The concept of cost-sharing will probably become more evident. The community that supplies new topographic mapping or survey data will be in a better position to convince FEMA to perform a restudy.

In conclusion, the procedures and policies for FEMA's Flood Insurance Study maintenance system are constantly evolving. The map amendment/revision process is sure to play a key role in the maintenance system's future.
MULTIPLE USE CONCEPTS IN FLOODPLAIN MANAGEMENT

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Introduction

A complete floodplain management program must include all activities necessary to reduce future flood hazards (preventive) while correcting past mistakes (remedial). These actions include land use controls; and the planning, design, construction and maintenance of flood control facilities.

Local governments, which are the agencies usually responsible for providing remedial flood control facilities, are being increasingly squeezed between revenues and the demand for services. The public wants relief from flooding problems while also looking for more amenities, including recreational facilities. It therefore makes sense to combine public uses whenever feasible. Flood control facilities, while necessary and useful, are dry most of the time; and are therefore available for other public uses (such as recreation and open space) which are compatible with the flood hazard.

Land developers also face multiple requirements when subdividing or building. These can include floodplain regulation requirements, park and school land dedication requirements, stormwater detention facilities, open space or landscaping requirements and marketing considerations. These requirements can break a project - or make it.

Both public agencies and private developers should look to the concept of multiple use to provide needed facilities and desirable amenities which improve the quality of life. Shared land, shared facilities, and shared construction and maintenance responsibilities can all help meet the needs of society at reasonable cost. Good planning can assure multiple use. Bad planning results in loss of opportunity for multiple use and higher costs to the public.
This is not a new concept but it is too often overlooked or ignored. The purpose of this paper is to focus on concepts of multiple use and examples of public-and private-sector multiple use projects in the Denver area.

Channels

Flood control channels, whether built for remedial purposes or as part of new development, offer the opportunity for greenbelts and trail systems. Maintenance trails can easily double as hiker/biker trails (Figure 1). Pocket parks can be created at intervals along the channels. These are small parks which can consist of playground equipment, benches, picnic tables, bicycle racks, exercise stations, drinking fountains, trash recepticles, etc.

The type of channel can obviously affect the amenity provided. For example, the Urban Drainage and Flood Control District (UDFCD) and the City of Denver had planned to construct a concrete channel for a section of Weir Gulch at its confluence with the South Platte River to remove a public housing area from the floodplain. A citizen's group called the Platte River Development Committee (PRDC, now the Greenway Foundation), which was revitalizing the South Platte River with parks, trails and other amenities, proposed a joint flood control and recreation project for Weir Gulch. With additional funds provided by the PRDC the three parties were able to acquire additional right-of-way which permitted the construction of a blue grass channel, boat launching lagoon providing access to the river, parking lot with basketball court, and play structure. The end result was a facility that not only provides the desired flood protection, but is a park for the housing area and provides a link to the South Platte River facilities (Figure 2).

Detention

Detention facilities can include every type of facility from major Corps of Engineers' flood control projects to the smallest of "on-site" ponds. Several examples of multiple use detention facilities are given below.

Holly Dam. Holly Dam controls a drainage area of 2.1 square miles. The 100-year flood volume of 252 acre-ft. will be contained in the flood pool which is owned by the South Suburban Recreation and Park District. The park district has
constructed tennis courts in a terraced fashion stepping down into the flood pool. The lowest courts are at the 10-year flood pool elevation. They have been flooded once in the 7 years since they were built (Figure 3). A soccer field was rough graded into the flood pool in the embankment borrow area at the time of construction but has not yet been developed. Maintenance of the facility is shared by the UDFCD and the park district.

Englewood School Detention. The UDFCD and the City of Englewood determined that the best solution to a flood control problem on Little Dry Creek was the construction of a side-channel storage facility to shave the peak from flood hydrographs. Fortunately, the ideal location for such a facility was the 11 acre athletic fields of Englewood High School. The School Board, although originally skeptical of the idea, eventually agreed to the concept. The resulting project provides 89 acre-feet of flood storage. In return for the authorization of the school board to use the land, the project added blue grass sod, one additional soccer field, concrete bleachers, concession stand and an office/press box. The school district maintains the bulk of the facilities, with the flood control maintenance responsibility limited to the inlet and outlet facilities, as well as after storm clean up.

On-Site Detention. Local on-site detention to maintain peak discharges at pre-development levels is required by many Colorado communities. These facilities can be stuck away in a corner where they are neglected, become maintenance problems and/or loose their effectiveness; or, they can be integrated into the overall development plan where they become assets to the development, and, because they are assets the chances of them receiving the needed maintenance are greatly enhanced. Figures 4 and 5 show how these on-site facilities can function as multiple use assets.

Open Space

Open space, particularly riparian land, is most beneficial to the overall quality of life of an area. In many instances in the Denver area, developers have found that the best way to address the flood hazard potential is to set the floodplain aside as open space area as an integral part of the development plan. With the addition of trails for hikers/bikers and for maintenance activities the
floodplains become linear parks and connecting links between different portions of the community (Figure 6). One caution is that the increased frequency and amount of runoff resulting from urbanization can cause significant erosion problems which should be addressed at the time of development.

 Trails

Trails are perhaps the most common example of multiple use. Every flood control facility, whether a channel or an open floodplain, should have a maintenance trail along its entire length. The UDFCD constructs maintenance trails along all of its channelization projects. The fact that these trails can also be used for hiker/biker trails is a bonus to the community.

On the other hand, trails built as hiker/biker facilities can also be used to provide access for flood control maintenance purposes. For example, when the Colorado Greenway proposed a trail along Bear Creek it provided the opportunity for the UDFCD to open up an almost inaccessible reach of Bear Creek by joining with the other trail sponsors to provide a part of the construction costs. The end result of the Greenway project was a recreational trail which also provides flood control maintenance access. Another example is a joint project between the UDFCD and the Greenway Foundation for a trail link along Lakewood Gulch from the South Platte River to a Denver park six blocks away (Figure 7).

 Guidelines For Multiple Use

Over the years the UDFCD has developed an informal set of guidelines to assist in the formulation of multiple uses. These guidelines are summarized below:

1. Uses must be compatible with the flood control purposes of the facility. Park, recreation and open space uses offer the greatest opportunity for multiple uses.

2. Public land is expensive to acquire and maintain. Multiple use can result in shared acquisition and maintenance costs. Look for right-of-way already in public ownership, or look for a potential "partner" in the use and maintenance of a project site.
3. Consideration of multiple use possibilities should begin early in the project planning stage. Multiple use should always be foremost in the minds of the planners.

4. Multiple use facilities develop a greater constituency for their continued operation and maintenance than single purpose projects, particularly flood control projects which function only occasionally.

5. Multiple use typically involves more than one agency. Future responsibilities; particularly maintenance, public safety and liability exposure; must be understood and accepted up front.

6. Multiple use can be stimulated by local governments through many avenues, such as the transfer of development rights.

A Final Example

Diligence in the pursuit of multiple use concepts for the Hidden Lake Outlet Channel project resulted in a unique multi-faceted project involving several agencies. The situation at the beginning of the project was this. The Hidden Lake Dam embankment had been declared unsafe by the State Engineer. The lake provided a valuable benefit, however, in reducing downstream flood peaks and the UDFCD wanted to insure the continued existence of the reservoir in order to decrease the required size of downstream channel facilities. The right-of-way needed to construct the required outlet channel, service spillway and emergency spillway consisted of two parcels: the Shattuck parcel, consisting of 9.7 acres; and the Kareus/Sullivan parcel of 6.0 acres.

The following arrangements were developed to secure the acquisition and long term use and maintenance of the two parcels. The Shattuck parcel was acquired through negotiation; with Hyland Hills Metropolitan Recreation and Parks District, Adams County Parks and the Land and Water Conservation Fund providing $197,000 and UDFCD and Adams County Public Works providing $35,000. The Kareus/Sullivan parcel was acquired through eminent domain proceedings by UDFCD and Adams County Public Works at a cost of $222,156.

Title to the Shattuck parcel was vested with Hyland Hills, and the flood control interests were given easements for the outlet channel, service and emergency spillways and embankment. Title to the Kareus/Sullivan parcel rests with UDFCD,
although it will eventually be transferred to Adams County. Hyland Hills has executed a long term lease with UDFCD for the use of the parcel with such uses being consistent with the proposed emergency spillway. Hyland Hills has constructed four ball fields on the two parcels using proceeds from the Colorado Lottery. A major concession facility is also planned.

The end result of this project is a 15.7 acre park and flood control facility. The combined funding (from 6 sources) resulted in facilities which would have been significantly more expensive to implement independently. The UDFCD will maintain the flood control facilities, while Hyland Hills will maintain the ball fields, including the emergency spillway area.

Summary

Multiple use concepts are a viable way in which to combine uses of land and monetary resources to obtain multiple objectives at a lesser cost to each of the individual interests. Flood control uses are particularly suited to be combined with park, recreation and open space uses. Examples of various types of multiple use projects in the Denver area demonstrate the value of this concept.
Figure 3 - Holly Dam tennis courts flooded

Figure 4 - Detention in a park

Figure 5 - Skyline Park in downtown Denver

Figure 6 - Open space trails and picnic area

Figure 7 - Lakewood Gulch Trail
DENSITY DEVELOPMENT CRITERIA
FOR FLOODWATER CONVEYANCE

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The concept of limiting development density has been used for such planning purposes as 1) maintaining agricultural and forest uses, 2) discouraging certain types of development, and 3) restricting development in order not to overstress existing services. Typically, specifications for lot size, volume of structural development, and configuration are components of density criteria. This same concept has numerous applications in flood-prone areas where maintaining adequate floodwater conveyance area is the objective. This presentation will explain these applications and will illustrate mechanics and case studies.

The floodway concept is one of the two major floodplain management tools used in the United States. The other tool is the elevation criteria for new structures. The floodway is specifically required in the regulations of the National Flood Insurance Program for most participating communities, and is a component of the floodplain programs of virtually every other governmental program which deals with floodplains. Under the floodway provision, a designated area within the floodplain won't be encroached upon, thereby assuring that floodwaters of the 100-year magnitude will pass with no more than a one-foot rise. This rise is caused by, and allows for, encroachment in the fringe area up to a total filling. In the "standard" floodplain configuration consisting of a defined channel and a floodplain where topography gradually rises away from the channel, the conventional floodway is, indeed, appropriate. In most cases, the central portion of the floodplain will contain waters of the greatest depth and velocity.

Therefore, the "conventional" floodway located by the equal conveyance principal will usually coincide with this central area of greatest hazard, though another hydraulically feasible location may be adopted. In any case, the location chosen, in order to be hydraulically efficient, would generally coincide with the area of greatest depth and velocity.
This fairly central location of the floodway can be justified, then, not only on the basis that conveyance must be reserved, but that this area, because of its relatively high hazards, should be most severely restricted regarding habitable development. Because of this additional supporting fact, the "conventional" floodway, located by the equal conveyance displacement principal, is normally understood and accepted by the public.

Where the floodplain is not typical, however, the applicability decreases. The following figures illustrate a "typical" floodplain and two that are atypical. It may be somewhat misleading in parts of this country to call these two atypical since, though they are rarely seen in standard documents or literature illustrating the floodway concept, their occurrence is fairly frequent.

FIGURE I
"Typical" equal conveyance floodway located between dashed lines. Floodway contains deepest and fastest waters. It covers the most efficient conveyance area.

(Section View)

(Plan View)
As can be seen in Figure 1, the conventional floodway location is both administratively and hydraulically "clean." It can readily be calculated with standard methods by any flood insurance study contractor and is easily delineated on maps and within zoning ordinances. The figure indicates that the two fringe areas could be completely filled and the floodway area could still pass the flood flows without exceeding the allowable predetermined surcharge. In FEMA's case, this is a maximum of one foot. It is this type of floodplain around which most regulatory criteria, including those of the NFIP, are written and to which the standard floodway hydraulic computer program is adapted.

It should be noted that a hydraulic reason for the floodway location coinciding with the fastest and deepest water is that more water passes through more quickly in this area than in the fringe. Therefore, it is the most efficient area in terms of conveyance. An area of equal linear size in the fringe would not pass as much floodwater during the same time interval.

A second type of flood plain is one that is "non-typical" in the sense that the most hazardous waters are not centrally located in the floodplain. This is shown in Figure 2.
Because the channel is not lower than all the surrounding floodplain (i.e., the topography does not slope up from the channel), the most hazardous floodwaters are not located centrally, but in the two deep areas outboard of the channel.

The standard equal conveyance calculations would delineate a floodway shown by the dotted lines (•••••). However, common sense and good engineering judgement would indicate that such a central location is inappropriate. Such a location, though acceptable by the standard hydraulic computer model, would encompass neither the most hazardous area nor the most efficient flow area.

The two locations encompassed by (□ □ □ □ □) indicate two areas through which portions of the floodwaters could logically be passed. This would represent a split floodway configuration that would encompass the most effective flow areas. In addition, it would seem logical that these areas should come under the most severe regulations, the floodway development constraints.

As one can imagine, it would be very difficult to sell the idea that the area between the dotted lines (the equal conveyance location) should not be encroached upon, while the fringe could be completely filled. This would not only run contrary to sound environmental practice, but would be much more expensive to develop than would be the high ground area closer to the channel. The split floodway, with its fringe areas located where there is the least flood hazard, would be more economically developed while also being supported by common sense.

The split floodway concept was adopted for use several years after floodway regulations were generally accepted. Though it was the target of some resistance from FEMA, the Corps of Engineers, and other engineering staff, it was applied in a limited number of cases and has now become a frequently accepted method of floodway location. Since in those cases where it has been appropriately applied it has appeared to be the most logical choice, this location alternative has been much easier to "sell" to the public.

To the layperson, it appears to encourage development away from the worst areas, and into the "safer" areas. Though not presented on Figure 2 for reasons of visual clarity, the natural channel itself would also be designated as a floodway area. This would be the case in any type of floodplain configurations.

The second type of "non-typical" floodplain is shown in Figure 3. In this
type, the hazard, with its components of depth and velocity, is generally constant from one edge of the floodplain to the other. In other words, the hazard at A is equal to the hazard at B. The standard equal conveyance floodway can be easily computed and delineated. It is also as easy to describe on a map and in an ordinance as was the example shown in Figure 1.

![Diagram of floodplain and floodway](image)

The paramount difference is that though the hazards are equal, the floodway regulations, particularly those of FEMA, treat A and B far differently. A, being in a fringe, has the ability to completely fill the property. Of course, any structure would have to meet applicable elevation requirements, but the owner could fill the areas with earth, concrete, or any other encroachment up to a total fill and still be within FEMA criteria. There could be as many habitable structures as the owner pleased on the property. B, however, could not, for most practical purposes, fill any of the property and could only build a structure if there was a detailed engineering analysis to demonstrate this the structure, along with all future anticipated possible developments, would not cause any rise in water surface elevation. Though the regulations envisioned no development in a floodway, it has been found that some very limited types of structures can be placed in a floodway without causing any measurable rise in water surface elevation. However, his kind of effort is both time-
consuming and costly and, very often, not really practical.

The reason B, and others inside the floodway, cannot cause any rise is that the allowable surcharge (e.g., FEMA's one foot) has been "used up" by the designation of the fringe as an area where unregulated encroachment can take place. Though, in reality, the fringe in most cases would not be totally filled, only by making this assumption is a community able to allow any measure of development without having to make a detailed case-by-case analysis to measure the encroachment potential of each development.

The inequity of the situation becomes apparent. The only significant difference between A and B is that B is unfortunate enough to be on the wrong side of the floodway line. B and other neighbors within the floodway are shouldering the entire burden of conveyance assurance, while A and neighbors are enjoying full use of their properties at the expense of B.

The density criteria are designed to alleviate this inequity while at the same time assuring that an adequate conveyance area is provided. The density concept is based on the principal that the burden of assuring adequate conveyance can be shared among all floodplain occupants who are subjected to similar hazards.

Figure 4 shows a floodplain configuration onto which no standard floodway has been drawn. The plan view shows, approximately to scale, what would be developed when density criteria have been imposed. The criteria for this example are those currently used by the City of Richland, Washington.

By applying the development criteria shown across the entire floodplain, the imposition of a designated floodway was avoided. Every property owner had to bear some of the burden of conveyance assurance, but these constraints allowed an economically reasonable use of the land for all. Not every parcel in the floodplain was exactly five acres in size when the criteria were imposed. Those that were smaller than five acres could not be built upon, and those smaller than ten acres could accommodate only one habitable structure which had to meet the rest of the criteria. Since existing structures are taken into consideration during the calculation of the base flood elevations (BFE) for the area, encroachments (structures, fills) were already considered in determining the flooded area and elevations need not be included when calculating maximum density allowable by the one-foot surcharge regulation.

The density criteria are only an option for floodplain configurations shown in Figures 3 and 4 because an argument for density criteria should be
made only when the hazard components of depth and velocity are generally constant. It can further be shown that if the product of these two components is constant, it makes little difference how great that product is since the equal conveyance floodway fringe regulations would allow habitable structures to be built anyway. In other words, even if the depth or velocity or both are great, the greatest restriction FEMA could place on new development is that only the floodway area could be preserved, while the fringe, with this same magnitude of hazard, could be completely developed.

The technology for analyzing density criteria for conveyance maintenance is now available, as is documented in a study done by the Army Corps of Engineers Hydrologic Engineering Center (HEC) for FEMA. While the method produced by this study has not been widely applied, those who have used the
method seem to be pleased with the results. Any engineering firm capable of using the HEC programs and/or producing a flood insurance study would also be capable of running a density criteria analysis. FEMA Region X has recently funded Corps sponsorship of a training session for all Corps’ Districts within the region on the use of the method.

In conclusion, the advantages of a density criteria are: 1) the burden of development restriction is spread to all property owners in the area, 2) properties of equal risk are regulated equally, and 3) no arbitrary placement of varying restrictions (i.e., floodway/fringe) is necessary. These advantages can make administration of floodplain regulations much more acceptable to local property owners. The approach can be utilized in areas with various degrees of mapping accuracy (approximate to very detailed), and be made to comply with various government regulations (Section 60.3(c)(10), NFIP). Its most obvious application is in areas where detailed floodplain data are available, but a regulatory floodway has not been provided. It can also be used in shallow flow areas and as a supplement to a regulatory floodway.

Cases in which density criteria have been adopted demonstrate that it is a workable concept and one that achieves conveyance assurance while providing a high degree of equity. These cases include Richland, Washington; Scio, Oregon; and Tualatin, Oregon.
A CONSULTING ENGINEER'S ASSESSMENT
OF THE NATIONAL FLOOD INSURANCE PROGRAM

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Introduction

One of the basic requirements of the National Flood Insurance Program (NFIP) is a flood insurance study (FIS), which determines water surface elevations in flood-prone areas. The Federal Emergency Management Agency (FEMA) has responsibility for supervising these studies, which are contracted to public agencies and private consulting firms. The writer has been involved in the performance of seven major FIS contracts and appeals, resulting in mapping of over 20 different cities and counties. As a result, he has experienced a number of levels of the NFIP, from fulfilling its technical requirements to interpreting its results to the public.

This paper offers an assessment of the NFIP from the viewpoint of a consulting engineer working as a study contractor. Areas of consideration consist of the FIS "Guidelines and Specifications," involvement of federal and state floodplain agencies, involvement of community officials, and public participation. Recommendations are presented regarding practical solutions to identified limitations or problems with the present NFIP from the engineer's perspective.

FIS Guidelines

The FIS "Guidelines and Specifications" have been developed by FEMA to outline the technical procedures to be followed by the study contractor in performing the engineering study. These Guidelines provide direction for conducting tasks related to reconnaissance, surveys, hydrology, hydraulics, mapping, report preparation, and coordination. The purpose of the Guidelines is not to be a definitive manual for hydrologic and hydraulic analyses, but rather to assist experienced engineers in selection of the most appropriate methods for use in the FIS. The Guidelines must be general enough to provide a nationwide standard for conducting floodplain studies in a wide variety of areas.

In recent years, FEMA has made efforts to develop more detailed study
procedures for certain types of flooding conditions. As a result, technical appendices and addenda have been prepared for the Guidelines which address coastal flooding, shallow flooding, alluvial fan flooding, and levees. These supplements are extremely helpful to the engineer and save considerable time during the study which might otherwise have been spent coordinating study methods with the PO and community officials. Further efforts to develop specialized study criteria for unique classes of flooding would be valuable in reducing the time and cost required for future FISs. Situations we have encountered in prior studies in which efficiency could have been improved by a new or expanded technical appendix include:

1. Desert watersheds and floodplains in which sediment and debris bulking and channel migration are important factors.

2. Extensive areas subject to ponding due to negligible gradient and levee systems.

3. Alluvial fans. Present procedures (i.e., the "Dawdy Method") are adequate only for simple (young) fans. Methods for handling more complex fans are being studied by FEMA and should be incorporated into a new technical appendix soon.

An area where the Guidelines should be relaxed is in the use of rainfall-runoff models (e.g., TR-20, HEC-1) to perform hydrologic analyses. At present, these models may be used only on unaged streams when no regional methods are available. However, in many cases, a rainfall-runoff model which is developed using site-specific data can be a better tool in predicting flood flows than a regression equation that may be based on spatial averaging of only two or three measurable parameters (e.g., area, mean annual precipitation). With improving computer capabilities and software, more defendable hydrologic results should usually be obtainable for unaged watersheds using tailored rainfall-runoff models rather than generalized regional regression equations. It is suggested that this approach become the norm rather than the exception in study areas with little or no historical streamflow data.

The discussion over whether movable bed hydraulic models (e.g., HEC-6) should be used to compute flood profiles in alluvial channels has continued for several years. Although the technology is presently available to model channels susceptible
to scour and sedimentation, the validity of this technology to an FIS is questionable due to substantial data requirements, difficulty of calibration, and expense. Although it would appear that it is not yet cost effective to apply movable bed hydraulic models to FISs, FEMA should continue to evaluate these procedures and incorporate them into the Guidelines at a time when the volume of available data and the expertise of the engineering community make their use economically feasible.

The Guidelines require preparation of a very standardized FIS report and map which are the only formal results of the study. The report and map focus primarily on the floodplain management aspects of the study, and thus, much of the technical material developed by the engineer is never presented in report form. The effort invested in conducting an FIS would be more valuable to the engineering community if a separate technical report were prepared by the study contractor in addition to the standard FIS report. This technical report should include detailed discussions of hydrology (statistical methods, raw data, model parameters), hydraulics (HEC-2 input, modeling techniques, alternative floodways), and recommendations for further floodplain analysis and for providing solutions to identified flooding problems. The last item is an important but often overlooked benefit of the FIS. An engineer who has studied and mapped a floodplain is in a good position to recommend alternative flood control plans aimed at mitigating problems identified in the study. Without this element of a technical report, much of the engineer's insight regarding the study area is not utilized.

**State and Federal Water Resources Agencies**

There are two primary levels at which state and federal water resources agencies become involved with the engineer during the performance of the FIS: 1) providing basic data and previous studies at the outset of the analysis; and 2) coordination of hydrologic results and other results of the study. Both activities can involve interaction between the engineer and state floodplain management agencies, state water resources departments, U.S. Geological Survey (USGS), U.S. Army Corps of Engineers (COE), U.S. Soil Conservation Service (SCS), and others.

It has been our experience that involvement by state agencies in FISs performed by private consultants varies from no involvement to extensive involvement. The most
active involvement tends to come from state agencies which occasionally serve as FIS contractors themselves. State agencies which are interested in our work but do not have direct experience as FIS contractors often find themselves with differing expectations and desires from the FIS than FEMA. As a result, the study contractor may be asked by state agencies to perform analyses and provide information which are outside the scope of work of a normal FIS (e.g., more detailed hydrologic or hydraulic analyses, consideration of future conditions). State water resources agencies could improve their efficiency in obtaining desired engineering material by cooperating with FEMA in the funding of FISs. In this way, state agencies would be able to make maximum use of the basic FIS itself and, with a relatively small investment of funds, could allow the study contractor to extend the analysis to meet specific needs of state floodplain managers. In addition, consultants would be able to produce higher quality studies if states were more prepared to provide related data and reports and to assist in coordinating hydrologic and other study results.

Assistance provided by federal agencies in making backup data and reports available to the private engineer has been only marginally helpful in the past. In general, the staffs of these agencies (USGS, COE, SCS) are too busy to do more than the minimum in coordinating with outside consultants. For example, the COE frequently has a significant amount of useful open-file material available, but the consultant is required to travel to the COE office in person, sort through the file material, and copy what he thinks will be helpful. A more widespread use of computerized databases by federal water resource agencies (similar to the USGS computer files of streamflow data and flood frequency analyses) would assist private firms in gaining access to this public information.

The study contractor is required by the Guidelines to submit hydrologic results to federal and state agencies for coordination. About half of the time these agencies are able to provide constructive review comments, but the other half of the time their staffs are either too busy to review the discharges and study methodology or they have no data or previous studies with which to compare the proposed flows.

It has been our experience, however, that federal agencies having current or proposed projects in the FIS study area take an active interest in our work and are willing to provide more direct, constructive input. Occasionally, this can be a problem when the goals of the federal project are different than those of the FIS,
because considerable coordination may be required to assure that the correct data and study procedures are utilized for each project and that the results are consistent. An excellent example of this situation is southern Nevada (Las Vegas and vicinity), where the FIS is being performed concurrently with reconnaissance-level flood control studies by both the COE and SCS. The consultant and the federal agencies have each exchanged information a number of times which has been mutually beneficial, and coordination of results and procedures has been extensive.

We believe that for most FISs performed by private consultants, more interest and constructive review by federal agencies could greatly improve the efficiency of the work and the quality of the product. One possible aid to this situation would be to include in the NFIP procedures a stipulation that as soon as a specific study package is advertised by FEMA, all appropriate federal agencies would begin collecting pertinent engineering data and previous studies. In this way, the agency would be able to accumulate the related material as time permits, and yet it would still be ready for the contractor at the very outset of the study. As a benefit in return, it is recommended that at the completion of each study, a technical report, as previously discussed, should be transmitted directly to interested agencies for their information and use on concurrent and future flood control projects.

Communities

The engineering and administrative staffs of communities for which detailed FISs are being performed are in a potentially awkward position. A technical floodplain study is conducted for their community which will serve as a basis for future floodplain management and flood insurance rates, yet the technical criteria for the study are determined by an outside (federal) agency and the community has no voice in selection of the consultant. Thus, it should come as no surprise that cities and counties are often relatively uninvolved in the project until the technical work has been completed and it is time to apply the results.

There are at least three reasons why it appears that community officials tend to remain uninvolved in the technical aspects of the NFIP. The first is what seems to be a general distrust of federal programs and administrators which threaten to increase outside regulation over local issues at the expense of local control. Second, local officials would be more interested in providing input to the technical...
FIS if the goal of the NFIP were solving flooding problems (i.e. designing and funding projects) rather than merely identifying and mapping them. Finally, many communities, particularly smaller ones, simply do not have the technical data or resources available to provide extensive assistance to the engineer.

The frequent lack of involvement of local communities in the FIS process is unfortunate because involved communities invariably receive better floodplain mapping. In addition, an involved community can often benefit tremendously from the FIS by using the technical data (aerial mapping, hydrology and hydraulics) for its own stormwater management efforts. Most communities do not realize that in the technical analyses performed by the study contractor they could have information useful for feasibility studies of channel improvements, detention basins, and bridges and culverts. The preparation of a formal technical report in addition to the standard FIS report would help make the engineering data required for stormwater management more readily accessible to the studied community.

Communities also often fail to realize the value of an engineer who has developed an understanding of regional and local flooding problems as a result of performing the FIS. The engineer is in an excellent position to provide the community with services in stormwater management in a very efficient manner due to the in-house data and technical tools obtained from the FIS. If a community has the foresight at the beginning of the FIS process to plan to employ the study contractor for its own project, then it can coordinate closely with the engineer throughout the study and thereby maximize his efficiency in performing the community's project later on.

How should community involvement be fostered within the bounds of the NFIP? First, FEMA should continue to stress to the community the importance of close coordination with the study contractor. However, the primary responsibility for educating communities should fall to the study contractor. The engineer is in the best position to objectively encourage participation in the study by the community and keep it informed regarding technical developments. An extension of this would be to allow communities to share a portion of the cost of the study in return for expanding the scope of work to include areas, methodologies or assumptions (e.g. future conditions) which are of interest to the community but which are outside the normal FIS scope.
Second, the engineer should be required to hold formal monthly or bi-monthly progress meetings with the community, attended also by FEMA if desired. The meetings would prevent the situation in which the community meets with FEMA and the engineer at the initial scoping meeting but has little or no contact with either until the preliminary study results are presented.

Third, the technical information generated by the engineer should become the property of the community (or the appropriate state repository) at the completion of the study. The engineer should hold a formal meeting with the technical staff of the community to explain this material to them. In this way, the information would be available to the local community to assist them in their own floodplain management and drainage control efforts, rather than remaining with the engineer and eventually being stored by FEMA.

The Public

As consultants who have conducted FISs in a variety of locations, it has been our observation that the public is almost completely unaware of the goals of the NFIP. Furthermore, the public is uninformed regarding the scope of work and level of detail of the technical FIS. These two factors lead to the development of misconceptions of the NFIP on the part of the public and make coordination difficult for the engineer.

Interaction between the engineer and the public generally is most intense during the initial data collection process and the final meetings to present the study results. Local residents living in flood-prone areas are often contacted when conducting field reconnaissance to obtain eyewitness accounts of recent flooding. Comments typically made by residents during these contacts include:

"Oh good, so someone is finally going to solve our flooding problem."

"You're wasting your time. I've lived here for 15 years and I've never seen any flooding."

"Flood insurance? I don't talk to insurance salesmen."
Despite the above initial reactions, observations of residents contacted in the field are often extremely helpful in evaluating flooding conditions. In the field, we have found that people are more free to talk to us if we avoid mentioning the words "federal government" and "insurance." Many study contractors would probably benefit from training in effectively soliciting public input in the field.

Public input at meetings where preliminary and final study results are presented does not usually result in substantive changes to the study. Attendance is generally poor, unless the community has experienced recent flooding, and those present are more interested in solutions to flooding problems rather than new maps. They have difficulty relating flood insurance maps to their own experience because they do not understand concepts of hydrologic frequency.

The question of how the NFIP can increase public participation in and awareness of the FIS process is a difficult one. The study contractor and community officials should meet at the beginning of the study to outline ways to solicit public input to the study and keep them informed of its progress. The approaches used to meet these objectives may be unique to each community but could include neighborhood meetings, special releases to newspapers (in addition to the formal notification), and delivery of special flyers to homes in flood-prone areas.

Conclusions

This paper has offered an assessment of the NFIP from the perspective of the consulting engineer involved primarily in the technical and coordination aspects of the program. Several specific recommendations for improving the NFIP have been offered. These have included modifications to the present FIS Guidelines, improved coordination with state and federal water resources agencies, and methods of increasing local community and public involvement in the FIS process. A key recommendation is to require study contractors to produce a technical report which would provide extensive detail on the engineering analyses performed. Such a report would be valuable to state and federal agencies as well as local communities concerned with stormwater management. Another key recommendation is to provide state and local floodplain agencies with the opportunity to contribute to the cost of the FIS and expand its normal scope to include other tasks specifically related to their own stormwater planning and management efforts.
Situated at the terminus of the Mississippi River drainage basin, Louisiana receives the drainage of 41 percent of the land area of the United States. Unlike the steep slopes and relatively narrow floodplains of the upper reaches of the river, the lower Mississippi flows through a wide flat-lying flood plain in which the natural levees are the highest topographic features. Early Louisiana settlers quickly recognized that flood control measures were essential to protect crops and populated areas, though initial efforts were rudimentary measures by individual landholders. Eventually, this responsibility came to be shared by parish governments, levee districts, the state, and the Federal government.

With each governmental entity focusing on problems within its legislated jurisdiction, measures were often devised that simply displaced the flooding from one locality to another -- solving a problem here, and causing one there. Due to increased development in flood prone areas and a series of unusual precipitation events, extreme flooding was experienced in the years between 1977 and 1983. In 1983 alone, more than $134.4 million was paid on over 16,500 flood insurance claims in Louisiana (F.E.M.A., pp. 183-204). This is approximately one-fourth of all claims paid in the United States for that year. With such significant damages, flooding became a major political issue in the state.

In 1982 the Louisiana legislature recognized the need for a unified approach to flood control problems and passed Act 351 creating the Statewide Flood Control Program. This innovative program provides state funding on a 70/30 percent matching basis to assist local governments in
dealing with flood problems. The program provides for long-term solutions to flooding without encouraging further development in flood-prone areas. For a proposed project to be considered eligible for participation in the program, it must have documented flood damages, have a minimum construction cost of $100,000 and have no adverse effects upstream, downstream or on adjacent areas. The program provides for a priority approach to funding these projects. Thus, for the first time, need, rather than political interest, was recognized as the primary factor in obtaining funding from the state.

To assist local governments in systematically evaluating drainage and flood problem areas, Act 351 required the Louisiana Geological Survey to develop and periodically revise a flood information base. As a result, the Louisiana Atlas of Flood Plains and Flooding Problems was prepared. (Available from the Louisiana Geological Survey, P. O. Box G, Baton Rouge, LA 70893). The Atlas combines Louisiana's hydrologic watersheds into 15 basins at a 1:250,000 scale. Each basin is depicted in a series of seven color maps showing recent geologic floodplain deposits, the 100-year floodplain, land use and land cover, soils, flood control projects, flood problem areas, and federal and state lands.

Act 351 also established the Flood Control Evaluation Committee, consisting of the Assistant Secretary of the Office of Public Works, the Director of the Louisiana Geological Survey and the Director of the State Planning Office or their designated representative. The Assistant Secretary of the Office of Public Works serves as Chairman. This committee establishes procedures for the implementation of the program. Toward this objective the "Guidelines and Procedures" for the program were developed and published. (Available from DOTD, Office of Public Works, P. O. Box 94245, Baton Rouge, LA 70804).

The Guidelines provide for a two-step application process. Local governments interested in participating must submit to the committee a preapplication and an application by May 1 and November 1, respectively. The preapplication emphasizes documentation of the flooding problem and is used to determine if the flood problem is eligible for assistance under the Statewide Flood Control Program. Once this decision has been made, the applicant is advised and, if determined
appropriate, is told to proceed with development of an application. The application is an engineering study which requires a technical approach to the resolution of the flooding problem. Sponsors whose jurisdictions include a population of less than 50,000 may request, in the preapplication, that the Office of Public Works provide engineering services to develop their application.

Once applications are submitted, the Flood Control Evaluation Committee begins a thorough review of each project. The varied backgrounds of the committee members allow for a multidisciplined review. The following subject areas reflect key factors which are scrutinized closely.

**Technical Feasibility** - The project must be designed in accordance with accepted engineering practice and must be certified by a professional engineer. A minimum return frequency of two years should be used for undeveloped areas and 25 years for developed areas. Hydraulic calculations, profiles and other technical data must be provided to verify that the proposed solution will bring about flood damage reduction as described. This data should define conditions before and after implementation of the project. The area which was flooded before but no longer floods after the project becomes the "benefited area".

**Consideration of Cost/Benefits** - While the program does not require a specific cost/benefit ratio, it does require that damage value calculations be determined for properties within the benefited area. Tables for this purpose are provided in the "Guidelines and Procedures". The cost of the project relative to the benefits that will be provided is an important factor in the scoring process which is used to prioritize the projects. Applicants should select the most cost-effective solution to their problem consistent with other program requirements.

**Environmental Considerations** - Applications must provide a preliminary assessment of environmental effects anticipated as a result of the proposed project. Parameters that must be addressed include water quality, habitat modification, fish and wildlife resources, noise and air quality, cultural, historical and archeological features and special geologic features.

**Consideration of Alternatives** - Floodplain management measures fall into two categories; structural and non-structural. Structural flood control alternatives include public works...
projects (pump stations, channel alterations, levees, stream diversion, etc.), storm water
detention and storm water retention. Non-structural flood control alternatives include flood
proofing, regulations, flood easement acquisition and relocations. The application should
address an adequate number of alternatives to ensure that the project was selected on the
basis of an objective analysis.

Local, State and Federal Agency Review - Applicants are required to submit comments from
nine state, local and federal agencies. This provides the Evaluation Committee with
valuable input from agencies that might eventually be issuing permits for the project. If
problems are anticipated, they can be addressed at an early stage of development.

After the Flood Control Evaluation Committee completes the review of these applications,
a prioritized list of projects is presented to the Joint Legislative Committee on Transportation,
Highways and Public Works. The Joint Committee then holds public hearings around the state to
accept public comments. Taking these comments into consideration, the Joint Committee
prepares a recommended construction program to present to the legislature. During regular
session, the legislature determines an appropriate level of funding.

In order to insure an equitable distribution of program funds throughout the state, a funding
formula has been devised. This formula is based on a two-tiered system which includes (1) the
nine major urban areas in Louisiana and (2) five funding districts for rural projects which generally
correspond to drainage areas in the northeast, northwest, southeast, south central and southwest
portions of the state.

Forty-five percent of total program funds is allocated to projects within the nine designated
urban areas. Projects within urban areas must compete with other urban projects for funding. No
single urban area can receive more than 20 percent of the urban allocation.

Fifty-five percent of total program funds is allocated to rural projects in the five funding
districts. Rural projects, based on structural density in the benefited area, are further subdivided
into rural developed and rural undeveloped categories. District funds are divided between the two
rural categories and projects compete within their designated category.
In the first year of the program (fiscal year 1983-84), the legislature allocated $25 million dollars which allowed for funding of the 16 top-priority flood control projects. Because it is still in the early stage of implementation, the success of the program cannot yet be evaluated. It may take several years for benefits to become readily apparent.

However, interest expressed by local governments can be measured. To date 188 applications have been submitted and of this number 66 have been recommended by the Evaluation Committee. Of Louisiana's 64 parishes 27 now have recommended projects. If all of these projects were to be funded, over $100 million dollars would be required.

Although Louisiana has experienced a reprieve from flooding since 1983, major precipitation events and increasing runoff from rural and urban development will assuredly occur in the future. In the past, these two factors combined with a politically based allocation of flood control monies has led to significant flood damages. However, with a statewide program that reduces further development in flood prone areas and reduces flooding in existing problem areas through objective, cost-effective, and prioritized funding, Louisiana should eventually be able to view flooding as a solvable problem, not as a way of life.

With the current trend toward reduction, and in some cases elimination, of federal funding for flood control, this financial responsibility will increasingly be borne by state governments. Across the nation, this will make prioritized, apolitical, statewide approaches imperative in years to come. The approach established in Louisiana with the Statewide Flood Control Program can be used as a model for other states in their efforts to combat flooding.

Reference

The State of Illinois has been in the water permit business since the early 1900s. Seeing the flood damage that development in and along rivers caused, the state legislature approved the Rivers, Lakes, and Streams Act in 1911. This law required permits from the state for construction within and along rivers, lakes, and streams. The law emphasized the state's responsibility to preserve the stream's carrying capacity in time of floods and under normal conditions. The Rivers, Lakes, and Streams Commission was then formed to oversee implementation of the act.

The Commission recognized and stated in its 1915 annual report that "repeated damaging floods make the question of flood prevention one of the most important matters for the consideration of the Commission." It also recognized the need for local cooperation in this task. In that same year, 1915, the Commission sent a letter to all the county clerks asking for their assistance in notifying it of any proposals to do work affecting stream drainage or flood flow, and requesting the county courts to withhold permission until the Commission could investigate and make recommendations on the acceptability of the plans.

The early history of the program is dotted with permit denials for building construction that would obstruct flood water. The program included an engineering staff, which made determinations of the impact of work on flooding. After this start, however, there were changes. The Commission was incorporated in the new State Department of Public Works and Buildings, Waterway Division. Emphasis was switched to construction activities from regulation concerns. World War II brought a significant reduction in the permit staff. The Division redefined its permit responsibility to include only a limited number of rivers and lakes and their adjacent banks, and levee work.

This narrow redefinition of the Illinois Statutes continued until the
1970s. In 1971, the Illinois legislature authorized the Department of Public Works and Buildings to implement floodplain regulations, much like Federal Emergency Management Agency's regulations, along streams where the Department proposed flood control projects. The goal of Illinois floodplain regulations was to protect new construction from increasing expected flood heights or from being subjected to flood damage itself. This legislation was adopted in order to get federal financing for flood control projects.

In cooperation with the Soil Conservation Service of the U.S. Department of Agriculture, we were able to develop floodplain mapping for five watersheds in the Chicago metropolitan area and to implement state floodplain regulations in these watersheds starting in 1975.

To implement our program, we held hearings and met with officials from every community or county affected. Since the floodplain regulations accompanied a locally supported flood control project, most local officials were eager to help us. The building officials were given a copy of our floodplain maps, which consisted of orthophoto topographic maps with two-foot contour lines at a scale of 1"=400'. The maps also indicated the approximate location of the 100-year floodplain boundary, floodway, and cross-section locations used in the computation of the flood profile. Since Illinois is such a flat state, any increase in flood stage can significantly increase flood damages; so we chose .1 foot as the floodway standard for Illinois. A 1"=400' accompanying floodplain profile map allowed users to determine the floodplain elevation at any location in the floodplain. Though the state law did not require local ordinance to adopt and enforce state floodplain regulations, the local officials were generally willing to use our maps and to refer anyone building in those areas to us for a state floodplain permit.

The floodplain regulation program was expanded and covered two additional watersheds, one entirely state funded project area in the Chicago area and a second project area funded partly by the Corps in the Rock Island-Moline area. We had ambitious plans to expand state floodplain regulations throughout the state when the Federal Emergency Management Agency's program caught up with us. Much of the state was being mapped for the National Flood Insurance Program. Dusting off our original legislative mandate (dating back to 1915) to "preserve the carrying capacity" of the state's streams in times of flood, we resumed regulating all floodways in the state. Using the floodplain data generated by the National Flood Insurance Program, we started requiring permits for work.
within the Federal Emergency Management Agency's defined floodways.

This new regulatory effort was publicized by the Division's Local Assistance Program. Since that Program's personnel coordinates the National Flood Insurance Program, they were an obvious choice to assist in getting local governments to send us floodway permit applicants. French Wetmore, our Local Assistance Program Chief, developed a nice "carrot and stick approach" to solicit local cooperation. He proposed a simplified model ordinance for local government. The ordinance required that a state permit or waiver of state permit be obtained before a local permit for floodway work could be issued. Having the tough judgment calls on floodway work made by the state, seems to make an easier ordinance for local government to administer. It also ties local officials to having state input before issuing floodway permits. The broadened regulatory effort really changed our role with many local governments. To start with, communities in which we already had state floodplain regulations found it much easier to adopt local floodplain ordinances, since their floodplain construction was already being regulated by us.

In most cases, we make the local building official's job easier. My staff consists of registered professional engineers, specialized in hydrologic and hydraulic analyses. We have found that many building officials do not feel comfortable deciding when a floodway obstruction is significant. Even if the community has a staff engineer, we have found that many of them do not have the technical background necessary to do a good job calculating flood impacts of obstructions. It took a lot of education on our part and our state coordinator's part to bring many of the municipal and consulting engineers up to date on current methods of hydraulic and hydrologic analyses. Many consulting engineers have had inadequate formal training in the intricate hydrologic and hydraulic analyses commonly used today in floodplain studies.

We also make the local's job easier because we are insulated from local politics. Even when the mayor knows a project doesn't make good floodplain management sense, it's a lot easier to say "go ask the state" than just "no." And even when the mayor is tempted to say "yes" he knows he is not doing his friend any favor if we come along later and stop the project. To date, the Federal Emergency Management Agency has accepted the state permit as meeting federal floodway requirements. Obtaining our permit is an easy way for the locals to show that they have met Federal Emergency Management Agency floodway concerns.
We find that having a state floodway permit program is a good check on how well locals are administering their ordinances. If state permit violations are found, the first party we turn to for assistance is the local building officials. Though many local officials are sincerely trying to do a good job, the complexity of the program overcomes them, or they process so few floodplain permits they forget established procedures. Our staff coordinates with local officials on all floodway permits and violations. If the local official seems to have some detail confused, we pass their name along to the state coordinator and the Federal Emergency Management Agency for a friendly visit or follow-up.

We also make sure that the cumulative or regional effects of the project are reviewed. Too often, local officials tend to think that the flood problems stop at their corporate limit. What advantage does the close coordination with local officials have for us? We don't have the staff necessary to handle all the floodplain questions or to police floodway construction. We felt able to comfortably expand our jurisdiction to all floodways of the state, only because we knew we would be working with the local officials as a first line of contact.

As we became confident in the local officials' expertise, we carefully delegated those parts of our authority that are duplicated or adequately handled by the local officials. For example, we no longer require flood fringe permits in the special state project floodplains if a community in the National Flood Insurance Program Regular Program issues its floodplain permit. Ridding ourselves of that duplication was applauded by everyone.

We are also continuing our efforts to educate our fellow engineers. We hope soon to have a manual prepared to help them better prepare calculations and permit applications. The manual should help them recognize when it is best to subcontract that analysis to an engineer specializing in hydraulics, rather than to struggle through it themselves.

It's been an interesting experience to administer Illinois' floodplain program through its evolution to its current status. The key to the program's success has been, and will continue to be, close coordination with local government.
STRATEGY FOR FLOODPLAIN MANAGEMENT FOR THE U.S. VIRGIN ISLANDS

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Background

The U.S. Virgin Islands is an unincorporated Territory of the United States located about 1,200 miles southeast of Miami, Florida. The Territory consists of three major islands plus about 50 smaller islands and cays. The islands have a total area of about 135 square miles and a population of approximately 100,000. The steep slopes, clayey soils, and intense rainstorms in the islands tend to create runoff with very high but short duration peak flows. Before major development occurred on the islands, these flows created few problems, since the runoff generally occurred in the cane fields, forests, or bush areas. Additionally, the towns and villages were heavily guttered or located on higher areas.

From 1960 to 1980, the Territory's population tripled. This population growth was accompanied by an era of extensive construction. Unfortunately, much of this construction occurred during droughty conditions in the 1960s, a time when runoff events were minimal and few regulations were in effect to control construction in the historic flood plains. Since about 1970, a number of major rainfall events have occurred in the Virgin Islands, causing flooding that has resulted in millions of dollars of damage to structures built in flood plains. In response, the Territorial Government instituted a long-term stormwater management and flood damage mitigation strategy that keys upon planning, regulation, construction, and education. This multi-phase approach to stormwater management should significantly reduce future flood damage.
Planning

Much of the initial direction for flood plain management came from the local office of the U.S. Soil Conservation Service (SCS) which established a strong Soil and Water Conservation District. The District encouraged: (1) the construction of dams; (2) the establishment of an earth change permit system; (3) the production of topographic maps; and (4) an engineering survey of the islands' major culverts.

In 1979, the Virgin Islands Disaster Programs Office (DPO) financed the production of a flood damage mitigation plan for the islands. This plan identified problems and solutions to the situation in the Territory, evaluated existing drainage problems, and provided guidance to avoid creating new ones. The plan outlined steps to be taken in the future, such as organization, construction, regulation, data collection, education, coordination, and budgeting. Since 1979, many of these steps have been taken by various governmental agencies.

Regulation

During the early 1960s, there were essentially no regulations that effectively regulated flood plain development. In 1971, an earth change permit system was instituted in the Territory. This required a special permit for any non-agricultural alterations to the land, including clearing, grading, and building. Some of the guidelines in the permit requirements concerned channel alteration and stabilization, detention storage, and land use in flood plain areas. The local SCS office was the major technical group in the enforcement of the rules, although the Virgin Islands Department of Public Works (DPW) was given authority.

In 1978, a coastal zone management act was passed to discourage further growth and development in flood-prone areas and assure that development in these areas is so designed as to minimize risks to life and property. The act re-emphasized and used many aspects of the earth change permit program. Its enforcement was divided between the DPW and the V.I. Department of Conservation and Cultural Affairs (DCCA).

In 1975, the Territory enacted legislation requiring demonstration that a
proposed structure was reasonably safe from flooding, before a building permit could be issued. The DPW and the V.I. Planning Office (PO) were given the responsibility to enforce this, using the 100-year flood elevation as a reference point. In addition to the above regulations, the PO continually updated draft subdivision regulations, which included provisions for regulating the construction of structures relative to the flood plain. Although not law, developers who were applying for subdivision permits were encouraged to fulfill the provisions.

The Territory has been involved with the national flood insurance program since 1975. In 1977, flood hazard boundary maps were issued to provide guidance for issuing flood insurance and for enforcing the flood hazard provisions of the building permit regulations. In 1980 the building code was modified to include and address standards necessary to permit the Flood Insurance Rate Maps (FIRM's) to go into effect. The initial studies were completed and the initial FIRM's were issued for the Territory. At the request of the V.I. Government, these were later modified to include topographic contours to facilitate their use.

Thus, in the past 10 years, the Territory has promulgated regulations necessary to manage flood plain development. However, the regulations have assigned responsibilities to a variety of agencies, and funding has been insufficient for thorough review and enforcement of the regulations. Moreover, the regulations are worded so that they unduly impose such rigorous engineering requirements on all applicants that they are often unenforceable.

Construction

The 1976 survey of 200 major culverts in the Territory indicated that many of the conveyance structures in the flood plains were not appropriate for the flows that were occurring. The Government embarked on a long-term construction program to alleviate some of the problems. In 1979, and again in 1982, selected drainage basins were studied to produce a series of drainage master plans to provide guidance in upgrading the structures within specific basins. This allowed the Government to upgrade individual structures anywhere within a basin, as monies were available, in a manner harmonious with the overall plan for the basin. This ongoing construction
The educational program of the Territory's flood damage mitigation strategy is concerned with public awareness and technical education. As a part of public awareness program the DPO wrote and published annual editions of "Surviving the Storm" for the past five years. This brochure outlines specific steps the public can take to prevent and recover from flood damage due to tropical storms and hurricanes.

The technical education program focuses on three areas for flood damage mitigation: design, regulation, and construction. Two types of design considerations are important in the program: the design of structures that are meant to convey flood flows, and the location of structures relative to the historic flood plains. The key element of the technical educational program for the design phase is a technical procedures manual entitled, *Drainage and Flood Plain Management Technical Procedures for the U.S. Virgin Islands*. This manual identifies basic data on the rainfall, land use, soil types, and topography that should be used in making the calculations for design and presents available procedures that could be used for performing relevant hydrologic and hydraulic calculations. These procedures cover such items as hydrographs; runoff rates; channel routing; and designs for culverts, channels, gutters, and storage basins.

The manual is intended for use by the local design professionals as a tool in locating and designing stormwater-related structures and that the government regulatory personnel use the manual to review the procedures involved in design. Sample problems and solutions based on local examples and data are included in the text. A series of workshops was held for Government engineering and regulatory personnel to review the material. This proved to be useful, since most of the regulatory personnel reviewing permits do not have a background in engineering or hydrology.

Regulatory functions relating to flood plain management are fragmented throughout the local Government due to the manner in which the regulations were passed and inserted in the statutes. Thus, various aspects of flood plain
management are often handled by different agencies without full awareness of the overall action that should be taken. To mitigate this problem, an educational program was initiated, which consisted of producing a regulatory handbook and holding a series of training workshops. The handbook, entitled, *Regulatory Handbook for Flood Damage Mitigation in the U.S. Virgin Islands* is a compilation of most of the applicable regulations. In addition, it discusses the problems and objectives of flood plain management in the Territory and explains the legal liability of Government personnel in reviewing and approving permits.

A continuing series of workshops have been undertaken to: (1) review the existing regulations; (2) explore ways in which they could be implemented and/or strengthened and (3) improve the technical skills of regulatory personnel. These workshops brought together, for the first time, all the personnel who review permit applications throughout the Territory. This helped to clear up some misunderstandings of jurisdictional responsibilities and technical interpretation.

A number of structures that convey stormwater in the Territory have suffered considerable flood damage. Many of these, especially culverts, are built in the field by DPW road crews. These crews are often furnished with only the basic materials at the site and very little in the way of formal plans. They tend to use techniques and concepts that they have used in the past, some of which are better than others. However, with some minor modifications in the "field design," these structures could transport flood waters more efficiently, at little or no additional cost, and reduce damage to both the structures and surrounding property.

To this end, a booklet was written for the road crews, which illustrates some hydrologic and hydraulic principles that could assist them in their work. The booklet, entitled, "Culverts Count," was made in the form of a cartooned story illustrating the essential points in a graphical fashion that could be quickly read. The story is about local people and illustrates island situations and problems.

**Summary and Conclusions**

The Territory's flood damage mitigation strategy, although meant to be a
long-term program, is already having positive effects. A major emphasis of the program has been to focus on upgrading the awareness and technical skills of the regulatory personnel who review the plans and building permits for compliance with stormwater management regulations. As their confidence in their own understanding of the regulations and technical procedures has increased, their reviews have become more efficient and effective. This in turn is encouraging the local design professionals, other Government personnel, and developers to become better acquainted with the applicable regulations and procedures. This is beginning to result in designs and plans that are more appropriate for construction in and near the historic flood plains.

In general, the plan to attack the problem on multiple levels of regulation, construction, and education has been very effective in carrying out the Territory's overall flood damage mitigation strategy.

References


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PART FOUR

ON LOCATION
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DEVELOPMENT MANAGEMENT TO REDUCE COASTAL STORM HAZARDS

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Associate Director

Jane Hegenbarth
Research Associate

The Center for Urban and Regional Studies
University of North Carolina at Chapel Hill

We have been doing research on the use of development management programs and policies to reduce life loss and damages in hurricanes and severe coastal storms. Little systematic data were found on how coastal localities address the hurricane and storm threat. To gain a greater understanding of the programs and policies in place in coastal localities, we surveyed high-hazard coastal communities in the Atlantic and Gulf Coast states.

The questionnaire we used addressed these issues:

1) What are the major characteristics of coastal development, and what factors influence these patterns?

2) What types of programs and measures (including development management) are coastal localities using to reduce hurricane and storm hazards?

3) How effective are these programs and measures at reducing storm hazards?

4) What are the major factors which affect the political feasibility and acceptability of hazard mitigation measures, particularly development management?

5) What are the factors which influence the effectiveness of mitigation programs and measures, particularly development management?

Coastal communities were surveyed if they had a population of 1000 or greater, and contained V-zones, or velocity zones, as designed under the National Flood Insurance Program (NFIP). Surveys were sent to over 600 localities in 18 states (Alabama, Connecticut, Delaware, Florida, Georgia, Louisiana, Maine, Maryland, Massachusetts, Mississippi, New Hampshire, New Jersey, New York, North
Carolina, Rhode Island, South Carolina, Texas, and Virginia), with a 66% response rate.

The findings of the survey will be discussed with respect to what coastal localities are now using to mitigate the storm threat and to manage future development (for a more in-depth discussion see Beatley et al., 1985). Obstacles and arguments against the enactment of development management measures, and problems resulting from existing development management programs will be summarized and discussed with regard to the implications these have for planners, policy makers, and others concerned with the use of development management to mitigate severe coastal damages.

Survey Results

In aggregate, the surveyed communities displayed some general land use trends. Existing flood plain development within the hurricane-prone communities is predominantly single-family detached residential, while recent development in the coastal floodplains has shown increasing degrees of multi-family and commercial development (which includes recreational and motel/hotel). Many areas are significantly built out: in over one-third of the surveyed communities, hazard-free development sites—those outside of the 100-year floodplain—were considered scarce or very scarce.

The majority of survey respondents were at least somewhat familiar with state programs assisting localities in storm hazard management. Most had received some type of state assistance in the past five years, most frequently information on the NFIP and floodplain maps. One-half of the respondents indicated that their community had received assistance with disaster preparedness plans. In over one-half of the communities, a regional agency had been involved in storm hazard mitigation, most often in the preparation of a regional evacuation plan.

In addition, approximately 72% of the survey respondents indicated that their jurisdiction's governing body considered the threat of severe coastal storms to be at least a medium priority in the community, while almost half (46%) said that it was either a high or very high priority.

Techniques in Use

The survey asked about storm hazard reduction strategies and the use of programs to alter the coastal environment structurally, to strengthen buildings and facilities, and to manage development. The questions asked about the effectiveness of specific techniques or approaches in the respondent's locality
in reducing coastal storm hazards. Hazard-reducing programs were broken into three main categories: those that structurally alter the environment, those that strengthen buildings and facilities, and those that manage development. Programs that alter the coastal environment include shoreline protection and flood control works, and sand moving or trapping programs. These programs have widespread use, as shown in Table 1. Shoreline protection works, such as bulkheads and seawalls, were being used in more than two-thirds of the localities.

**TABLE 1: Programs to Structurally Alter the Environment**

<table>
<thead>
<tr>
<th>Method</th>
<th>Number of communities using technique (percentage of total)</th>
<th>Average Effectiveness Rating (on a 5 point scale)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Shoreline Protection Works</td>
<td>289 (68.8%)</td>
<td>3.20</td>
</tr>
<tr>
<td>(bulkheads, seawalls, revetments)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Flood Control Works</td>
<td>142 (33.8%)</td>
<td>3.47</td>
</tr>
<tr>
<td><em>(dikes, channels, retaining ponds)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Sand Trapping Structures</td>
<td>141 (33.6%)</td>
<td>2.72</td>
</tr>
<tr>
<td><em>(groins, jetties)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Sand Moving Programs</td>
<td>129 (30.7%)</td>
<td>2.77</td>
</tr>
<tr>
<td><em>(beach nourishment, beach scraping)</em></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2 shows the use of programs to strengthen buildings and facilities. Almost all localities had adopted the minimum elevation and floodproofing required under the NFIP (93.8%), and most had adopted a building code (90%). Almost half of the localities (46%) were using additional storm-resistant standards for coastal construction. While more extensive elevation and floodproofing requirements were only used by approximately 15% of the localities, they had the highest effectiveness rating of the listed policies.
TABLE 2: Programs to Strengthen Buildings and Facilities

<table>
<thead>
<tr>
<th>Method</th>
<th>Number of communities using technique (percentage of total)</th>
<th>Average Effectiveness Rating (on a 5 point scale)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Minimum elevation and flood-proofing required under the NFIP</td>
<td>394 (93.8%)</td>
<td>3.86</td>
</tr>
<tr>
<td>2. Building Code</td>
<td>378 (90.0%)</td>
<td>3.6</td>
</tr>
<tr>
<td>3. Special Storm-Resistant Building Standards</td>
<td>198 (47.1%)</td>
<td>3.82</td>
</tr>
<tr>
<td>4. Floodproofing of Public Facilities and Structures (sewer and water, roads, utilities)</td>
<td>161 (40.2%)</td>
<td>3.47</td>
</tr>
<tr>
<td>5. More extensive elevation and flood-proofing than required by the NFIP</td>
<td>62 (14.8%)</td>
<td>3.94</td>
</tr>
</tbody>
</table>

The survey asked a number of questions regarding the use of development management in these jurisdictions. "Development Management" was defined to include programs or policies which control or influence the location, density, timing, and type of development in a jurisdiction. (See Brower et al., 1984 for a general discussion of development management; and McElvea, Brower, and Godschalk, 1982 for an application of these techniques to hazard mitigation.) Twenty-one different development management programs or policies were listed for communities to identify as in use in their localities. Most local governments are using a number of development management techniques: 29% indicated that between one and five techniques were being used, almost 55% were using six to ten measures, 15% had more than 11 development management measures in use.

Table 3 lists the 21 development management measures by their frequency of use by the surveyed localities, and indicates their average perceived effectiveness at reducing storm hazards. Over 80% of the localities had zoning ordinances, subdivision ordinances, and land use plans; however, these three techniques were not rated as particularly effective in reducing coastal storm hazards. Special hazard area ordinances, while only in use in 26% of the localities, received the highest overall effectiveness ranking of 3.85 (on a
<table>
<thead>
<tr>
<th>Rank Order</th>
<th>Type of Measure</th>
<th>Number of communities using technique (percentage of total)</th>
<th>Average Effectiveness Rating (on a 5 point scale)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Zoning ordinance</td>
<td>368 (86.6%)</td>
<td>3.15</td>
</tr>
<tr>
<td>2.</td>
<td>Subdivision Ordinance</td>
<td>359 (85.5%)</td>
<td>3.06</td>
</tr>
<tr>
<td>3.</td>
<td>Comprehensive/Land Use Plan</td>
<td>352 (83.8%)</td>
<td>2.94</td>
</tr>
<tr>
<td>4.</td>
<td>Evacuation Plan</td>
<td>278 (66.2%)</td>
<td>3.54</td>
</tr>
<tr>
<td>5.</td>
<td>Shoreline setback regulation</td>
<td>225 (53.6%)</td>
<td>3.59</td>
</tr>
<tr>
<td>6.</td>
<td>Capital improvements program</td>
<td>222 (52.1%)</td>
<td>2.55</td>
</tr>
<tr>
<td>7.</td>
<td>Location of public structures and buildings to reduce storm risks</td>
<td>193 (46.0%)</td>
<td>3.66</td>
</tr>
<tr>
<td>8.</td>
<td>Dune Protection regulations</td>
<td>159 (37.9%)</td>
<td>3.68</td>
</tr>
<tr>
<td>9.</td>
<td>Location of capital facilities to reduce or discourage development in high hazard areas</td>
<td>131 (31.2%)</td>
<td>3.41</td>
</tr>
<tr>
<td>10.</td>
<td>Acquisition of undeveloped land in hazardous areas</td>
<td>121 (28.8%)</td>
<td>3.61</td>
</tr>
<tr>
<td>11.</td>
<td>Special hazard area ordinance</td>
<td>109 (26.0)</td>
<td>3.85</td>
</tr>
<tr>
<td>12.</td>
<td>Hazard disclosure requirements in real estate transactions</td>
<td>107 (25.5%)</td>
<td>2.92</td>
</tr>
<tr>
<td>13.</td>
<td>Transfer of development potential from hazardous to non-hazardous sites</td>
<td>89 (21.2%)</td>
<td>3.44</td>
</tr>
<tr>
<td>14.</td>
<td>Recovery/reconstruction plan or policies</td>
<td>88 (21.0%)</td>
<td>2.99</td>
</tr>
<tr>
<td>15.</td>
<td>Hurricane/storm component of comprehensive plan</td>
<td>81 (19.3%)</td>
<td>3.34</td>
</tr>
<tr>
<td>16.</td>
<td>Construction practice seminars</td>
<td>65 (15.5%)</td>
<td>3.22</td>
</tr>
<tr>
<td>17.</td>
<td>Acquisition of development rights or scenic easements</td>
<td>58 (13.8%)</td>
<td>2.88</td>
</tr>
<tr>
<td>18.</td>
<td>Reduced or below market taxation</td>
<td>45 (10.7%)</td>
<td>3.02</td>
</tr>
<tr>
<td>19.</td>
<td>Acquisition of damaged buildings in hazardous areas</td>
<td>14 (3.3%)</td>
<td>3.3</td>
</tr>
<tr>
<td>20.</td>
<td>Building relocation program</td>
<td>9 (2.1%)</td>
<td>3.33</td>
</tr>
<tr>
<td>21.</td>
<td>Impact taxes or special assessments</td>
<td>8 (1.9%)</td>
<td>3.75</td>
</tr>
</tbody>
</table>
scale of 1 to 5). Impact taxes or special assessments were also considered highly effective in reducing coastal storm hazards (a 3.75 effectiveness ranking), yet less than 2% of the localities have such programs. Dune protection regulations were considered the third most effective measure, and 38% of the localities have such regulations.

The survey also attempted to obtain insights into factors which influence the political feasibility of development management. Respondents identified what they perceived as obstacles in their community to the enactment of development management. These are listed in Table 4 by order of frequency.

**TABLE 4: Obstacles to the Enactment of Development Management**

<table>
<thead>
<tr>
<th>Attitude</th>
<th>Number of Communities with Attitude (percentage of total)</th>
<th>Importance Rating (on a 5 point scale)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. General conservative attitude toward government control of private property rights.</td>
<td>327 (87.7%)</td>
<td>3.35</td>
</tr>
<tr>
<td>2. General feeling that the community can &quot;weather the storm&quot;</td>
<td>317 (85.4)</td>
<td>3.07</td>
</tr>
<tr>
<td>3. Lack of adequate financial resources to implement mitigation programs</td>
<td>304 (84.4%)</td>
<td>3.41</td>
</tr>
<tr>
<td>4. More pressing local problems and concerns</td>
<td>300 (82.2%)</td>
<td>3.26</td>
</tr>
<tr>
<td>5. Lack of trained personnel to develop mitigation programs</td>
<td>287 (80.2%)</td>
<td>2.91</td>
</tr>
<tr>
<td>6. Lack of incentives or requirements from higher levels of government</td>
<td>286 (79.9%)</td>
<td>3.00</td>
</tr>
<tr>
<td>7. Opposition of real estate and development interests</td>
<td>294 (79.7%)</td>
<td>3.03</td>
</tr>
<tr>
<td>8. Opposition of homeowners</td>
<td>260 (73.9%)</td>
<td>2.63</td>
</tr>
<tr>
<td>9. Opposition of business interests</td>
<td>248 (70.7%)</td>
<td>2.59</td>
</tr>
<tr>
<td>10. Absence of politically-active individuals and groups advocating hurricane/storm mitigation</td>
<td>248 (70.7%)</td>
<td>2.82</td>
</tr>
<tr>
<td>11. Inadequate or inaccurate federal flood insurance maps</td>
<td>221 (62.3%)</td>
<td>2.48</td>
</tr>
</tbody>
</table>
The four obstacles cited by more than 80% of the responding localities were considered the top four in importance or severity: 1) the general conservative attitude toward government control of private property rights, 2) a general feeling that the community can "weather the storm," 3) lack of adequate financial resources to implement mitigation programs, and 4) more pressing local concerns.

Respondents also indicated the existence and importance in their localities of several popular arguments against development management. Almost 85% of the responding communities indicated that an important argument used in their community against the enactment of development management was that such measures lead to increased development costs. Other arguments cited by communities as important were: decisions about risks from coastal storms are best left to the individual (71%), development management measures will dampen the local economy (68.5%), and particular development management measures are illegal or unconstitutional (66%).

Regarding development management programs already in place, almost half (49%) of the respondents indicated that they had encountered implementation or enforcement problems. The most frequently cited problem was insufficient funds, mentioned by 60% of the responding localities. In addition, 46% noted problems due to public opposition, 43% cited a lack of support by public officials, and 41% noted that lack of qualified personnel was a problem. Other problems less frequently cited were an insufficient data base, opposition from developers, and public apathy. In addition, approximately one-third of the respondents perceived that their localities had experienced negative consequences as a result of development management programs. The great majority of these affected communities cited an increase in construction costs (84%), while much smaller percentages indicated that they had experienced slowed economic growth and development (20%), reduced tax revenues (15%), or reduced land values (11%).

Implications for Planning

Some important trends and relationships have emerged from these preliminary survey results which can provide insights for those concerned with hazard mitigation and the reduction of coastal flood hazards. Lack of adequate financial resources is cited as the greatest obstacle to development management—both in enacting measures, and in enforcing and implementing existing measures. Coastal communities frequently have limited administrative and financial capac-
ities, and may not be able to afford expensive land use or management studies. Historically, funds have been accessible for structural flood control studies and projects, while difficult to procure for non-structural hazard mitigation measures (Kusler, 1982, p. 71; David, 1984, p. 32). Structural measures have become increasingly cost-prohibitive to construct, expensive to maintain over time, and are often ineffective in reducing long-term coastal hazards. More permanent and cost-effective hazard mitigation solutions may be achieved at the local level through development management, but this will likely require financial support from state or federal sources.

Because of their financial limitations, many coastal communities cannot afford full-time planning staff, and where staffs exist, they may have limited technical capabilities. Further analyses of the survey data showed that the adoption of explicit hazard reduction strategies and development management measures were positively linked with both the community's population size, and number of planning personnel. Not surprisingly, communities with explicit hazard mitigation policies were linked with regional agencies active in storm hazard mitigation, and effectiveness of a community's development management program increased with the respondent's increasing knowledge of sources of state assistance. These illustrate the important role that state and regional agencies can play in assisting local communities with adopting hazard mitigation and development management measures. Outside technical assistance and expertise will also help local decision makers to consider hazard mitigation and development management measures with which they may be unfamiliar or inexperienced.

Political opposition, lack of interest, and more pressing local problems also appeared to created substantial impediments to enacting development management measures. State and federal regulations that require communities to address coastal storm threats through development management and other non-structural mitigation techniques help deflect public opposition away from local officials. In addition, it is widely perceived that development management measures may dampen the local economy and increase development costs; communities may be hesitant to enact measures because they perceive that they may become economically less competitive with other communities. Requirements from the state or federal level for such measures would eliminate this, while ensuring that all communities address at least a minimum of nonstructural hazard mitigation efforts. For instance, the North Carolina coastal management pro-
gram requires local land use plans for all coastal communities, and has recently passed a requirement that all communities address hazard mitigation and postdisaster reconstruction planning.

Strengthening state and federal support for development management will help to overcome obstacles and implementation problems, but to achieve successful and effective local programs, planners and policy makers need to address and diffuse the popular arguments and attitudes against development management. Some of these arguments may be based more on perceptions than experience--over 300 surveyed communities indicated that an argument against development management in their community was that increased developmental costs resulted from development management, but only one-third of this number had seen any such increase. Similarly, while "development management measures dampen the local economy" was an attitude existing in a great number of surveyed communities, very few actually perceived that their community had experienced slowed economic growth and development as a result of such measures.

Where measures have led to an increase in development costs, these can usually be explained as a shift of the additional costs required by coastal development from the community and public at large onto those who directly benefit from such development--the private developers and individual purchasers of hazardous development. Supporters of positions that advocate the rights of individual decisions regarding coastal development and risk-taking will have trouble justifying the use of public expenditures to help pay for the additional costs imposed by such development.

Advocates of development management need to emphasize other public issues affected by coastal development. The quality of public beach fronts can be deleteriously affected by unwise coastal development. Because of the public safety issues posed by hurricanes and severe coastal storms, the ultimate land use pattern and intensity of an area should not be created solely by private decisions regarding individual risks. The need for an adequate evacuation capacity, and the damage potential to neighboring properties created by storm-swept debris from hazardous construction highlight two of the unique public safety issues that are present in coastal development. Planners and policy makers need to emphasize such public safety issues to help overcome conservative attitudes toward private property regulation.

Finally, it is important for proponents of development management to fit hazard mitigation objectives into existing community goals and policies. The
survey results indicated a relatively high degree of local concern over the hurricane and severe coastal storm threat, but were less conclusive on the effectiveness of localities' attempts to address this concern through development management techniques. In many areas, local policy makers may simply be unfamiliar with the concept of reducing hurricane hazards through development management measures, addressing the threat by relying instead on strengthening and reinforcing the built environment, or by increasing evacuation capacity.

In many coastal localities, other more pressing concerns appear to create obstacles to the enactment of specific programs or policies for hazard mitigation. In these cases, effectiveness in enacting mitigation programs may be increased by combining hazard reduction policies with other community objectives. Case studies conducted of hurricane-prone communities indicated that hazard-reducing development management policies which were locally initiated were supported for a number of community goals. Related local issues that may garner broader support include desire for open space, public beach access, concern over aesthetics, and worry over water quality and other environmental impacts of development. Emphasizing the multiple community benefits that result from prudent hazard-reducing development management measures will help to overcome the existing obstacles to development management that still persist in many communities.

References


FLOODPLAIN MANAGEMENT IN SOUTHERN CALIFORNIA'S ANTELOPE VALLEY

James L. Easton
Los Angeles County Department of Public Works

Introduction

The Antelope Valley is located in the southwestern portion of the Mojave Desert in northernmost Los Angeles County. It has a population of over 100,000 people and is one of the fastest growing areas in Southern California. It's an area that has long been known for its agriculture, but in recent years two cities (Lancaster and Palmdale) have incorporated and are part of a rapidly expanding urbanized area. The Valley is also a center for several activities important to national defense; e.g., the construction of the B-1B and Stealth Bombers and the Air Force's experimental flight test and space shuttle activities at Edwards Air Force Base.

The Valley has rather unique and severe drainage problems that are not a great threat to agricultural interests but which are a substantial hazard to and are exacerbated by the rapid urbanization in and around the cities. If growth in the Valley is sustained and in order to protect its current residents, the cities and the Los Angeles County Department of Public Works are formulating and intend to implement plans for nearly $1 billion of flood control and water conservation infrastructure that will require the cooperation and participation of many governmental agencies, the public, and private land developers. It will use a combination of structural improvements and nonstructural flood plain management.

Physical Characteristics of the Valley

Climate

The Valley floor is desert with an annual normal rainfall of nine inches in the foothills to five inches at Edwards Air Force Base. In the adjacent San Gabriel and Techachapi Mountains however, rainfall is much greater and often more intense. Summer thunderstorms, although infrequent, can produce very high-intensity, flash flood-producing rainfall in the summer and fall.
Geography and Drainage

The Los Angeles County portion of the Valley has seven major drainage areas. Each begins in the mountains that bound the Valley on the west and south. Storm run-off from the mountain canyons has formed large alluvial fans across which it meanders in ill-defined and often-changing paths.

The Valley is a drainage basin with no natural outlet. The flow that does not percolate into the ground in the upper watersheds finds its way into Rosamond or Rogers Dry Lakes (Edwards Air Force Base) where there is practically no percolation. During rainy years, the lake beds may be flooded for several months.

Population

Much of the Antelope Valley is unimproved desert land. For many years, where water has been available, agriculture has and continues to flourish. The continued agricultural activities in the Valley plus a rapidly expanding population have caused serious overdrafting of the Valley's groundwater resources.

Several factors are causing population growth:

1. The aerospace industry is growing. The B-1B Bomber is being constructed there, and a new plant to build the Stealth Bomber is under construction. The Air Force Flight Test Program at Edwards Air Force Base employs approximately 2,000 people.

2. The on-again, off-again plans for the Palmdale Intercontinental Airport (a proposed supplement to Los Angeles International Airport) may ultimately lead to a substantial increase in commercial activity in the Valley, with attendant population growth.

3. Housing is reasonably priced, which is attracting people who work in the Santa Clarita and San Fernando Valleys, both of which are accessible within minutes via the Antelope Valley Freeway.

The new North County Element of the Los Angeles County General Plan provides for population in the Valley of approximately 218,000 in the year 2000.

Flood Plain Management Crisis

The urbanization of the Valley that has taken place in the past has not
adequately recognized the flood hazard from waters that leave the mountain canyon mouths and traverse the broad alluvial fans and ultimately flow into the dry lakes. Past residential development has been required to provide facilities only for the storm drainage from the site itself. This resulted in construction of storm drains outletting into on-site retention and detention basins. These facilities are not connected to any regional drainage facilities because none currently exist, with the exception of an improved open channel that serves the agricultural community of Littlerock and Amargosa Creek, an earthen channel through the City of Lancaster.

The severe flooding in the Valley that occurred during the storms of 1978, 1980, and 1983 focused the attention of the residents of the Valley and governmental officials on the fact that present and future development could not be adequately protected unless a plan were formulated and implemented to provide regional drainage facilities. A need to maximize conservation of storm runoff to replenish badly overdrafted groundwater supplies is also recognized.

The situation is complicated by the fact that no single public agency is currently responsible for flood control and water conservation in the Los Angeles County portion of the Valley. The Los Angeles County Flood Control District's northernmost boundary line is along the southern portion of the Valley and has prevented the District from extending its service to most of the Valley.

The Evolution of a Master Plan for Storm Drainage and Water Conservation

In late 1984 and early 1985, several things combined contributed to the formation of a master plan for storm drainage and water conservation in the Valley. The Los Angeles County Regional Planning Commission threatened a building moratorium in unincorporated territory unless such a plan were formulated. In the fall of 1984, the Los Angeles County Board of Supervisors consolidated the Flood Control District, County Road Department, and County Engineer into a single Public Works Department. Since the County Engineer is responsible for insuring that land development in the unincorporated area of the Antelope Valley proceeds in a safe manner, the new Department of Public Works was able to utilize the expertise of the Flood Control District in formulating a master plan for storm drainage and water conservation. This move was greeted with enthusiasm and cooperation from the two incorporated cities, the Air Force Base, the City of Los Angeles
Department of Airports, and the development interests. A plan is being developed for each of the seven major drainage areas within the Valley. As of April 1, plans for four of the areas are complete. The other three will be completed by June 30, 1985. In canyon areas, nonstructural solutions such as flood plain management techniques will be used to insure that future development is free of flood hazard. In areas which are or will become urbanized, the plans provide for retention or detention basins near the mouths of canyons and at other locations which will store peak runoff and maximize water conservation. Flows will be safely carried across the Valley floor in channels. Most of these will be earthen channels to maximize water conservation. In areas where flow velocities are slow enough, grassy swales may be utilized. In the two easternmost watersheds, Littlerock and Big Rock Creeks, more traditional methods of flood plain management will be used. A 4,000-foot-wide watercourse with lined levees is being considered for Littlerock Creek. Flood plain mapping and traditional flood plain management methods will probably be used for Big Rock Creek which is sparsely populated and is not used extensively for agriculture.

**Funding**

**Funding the Plan**

Total cost of producing the master plan for the seven drainage areas will be approximately $300,000. Funds have been contributed by the Cities of Palmdale and Lancaster, the Los Angeles County Flood Control District, and the County of Los Angeles. Allocation of some Federal block grant funds through the County is expected. Funding contributions are also being sought from the Air Force and the City of Los Angeles Department of Airports.

**Funding the Improvements**

In late 1984, the Department of Public Works convinced the Los Angeles County Regional Planning Commission to exact development fees for all tract improvements and lot splits in the Antelope Valley. The fees are $2,000 per single-family residence and $1,000 per multiple-family unit in tract developments and $10,000 per commercial-industrial acre. These fees are being required by the Regional Planning Commission as a condition of approval of tentative tract maps or lot splits. Currently, drainage fees are not required for development on previously
subdivided lands.

The developers are putting up bonds or callable letters of credit that will be held by the Department of Public Works until sufficient funds have been accumulated to begin work on specific high-priority elements of the master plan. This approach has been accepted by the development community and the Regional Planning Commission after some spirited discussions with the Department of Public Works.

Federal funding is also being sought. The United States Army Corps of Engineers has been studying the Antelope Valley streams for a number of years. $140,000 is budgeted for Fiscal Year 1985. An identical amount is recommended for Fiscal Year 1986. At that funding level, it is anticipated that the study will be completed in approximately 1990.

The Corps' efforts are being focused on quantifying benefits to the Federal Government attributable to the proposed drainage and water conservation improvements. It is believed that the most significant of these benefits will accrue to Edwards Air Force Base. The lake beds that receive storm runoff from the Valley are a vitally important feature of the Base. The Flight Test Program, the Space Shuttle Recovery Program, and the landing of damaged or disabled aircraft all require dry lake beds. However, during wet years, the lake beds may be flooded for several months. The benefit of having a system of flood control and water conservation facilities that will maximize the utility of the lake beds is very high. For example, the Air Force estimates that it has saved $8 billion worth of aircraft and a substantial number of lives over the past 25 years by being able to divert disabled aircraft to land on the dry lakes. The softer surface of the lake bed, the minimized danger of fire, and the absence of obstructions regardless of the path taken by landing aircraft have minimized damage and loss of life.

The Air Force needs some water in the lakes in order to smooth the ruts generated by wind and landing aircraft. It is believed that the flood control and water conservation system can be designed to provide an optimum amount of water to the lakes even though it will have to be done with some sacrifice of water conservation since water delivered to the lakes will evaporate rather than percolate.

The Department of Public Works will make available to the Corps its master
drainage plans and all of the supporting data as soon as they are complete. It is hoped that this information will be adopted by the Corps and expedite the conclusion of its study. Cooperation of the Air Force is also being sought for possible utilization of military funds for the construction of specific off-base improvements that will provide demonstrable benefits to the Base.

Federal block grant money is being considered for the construction of high-priority regional drainage facilities by both the cities and the County.

The City of Lancaster has also recently enacted development fees similar to those enacted by the County and will use those funds for regional and local drainage facilities within or near the city.

**Getting From Here to There--The Interim Program**

Because of the unique geography of the area, water will not follow the paths delineated in the master plans until the facilities themselves are built. For this reason, interim measures are being taken to protect future development. Developers will be required to construct streets that will be located so as to serve as temporary watercourses to conduct regional drainage safely through the tract. Lot pads will be elevated sufficiently to prevent flooding of adjacent homes. Facilities will have to be constructed at the upstream side of the tract to safely channelize flow into the streets and at the downstream side of the tract to safely dissipate the energy of water flowing in the street. There will be times when travel is disrupted by reason of the streets being used as occasional watercourses.

Developers are being encouraged to build portions of the regional system. They will receive credit for that construction against the drainage fees being exacted. They are required to dedicate the right of way necessary for the future facilities whether or not they choose to construct the facilities. Again, credit is given for the value of the rights of way.

Legislative action has been introduced to create a new Antelope Valley Flood Control District which, if enacted, will provide a single agency that will be responsible for the implementation of the regional drainage plan. It will also provide a local agency to act as partners with the Federal Government in cooperative local Federal construction.
Summary and Conclusions

Antelope Valley presents some unique challenges because of its climate, geography, and demography. Normal flood plain management approaches are not applicable in most parts of the Antelope Valley (i.e., the Valley floor).

The cooperative action now being taken by a number of governmental agencies and private developers will allow development to continue and provide funds for the construction of the most-needed elements of a regional drainage system. The system will utilize a wide variety of flood plain management techniques ranging from concrete-lined channels to grassy swales. It will protect a large urbanized area, maximize water conservation, and provide more utility of the dry lakes at Edwards Air Force Base.

South of the mountains in the Los Angeles Basin, the flood control and water conservation system was constructed largely after development had taken place. The Antelope Valley provides an opportunity to construct this important infrastructure as development takes place but will require the continued close cooperation of developers, government, and the public. The Department of Public Works intends to meet that challenge.
FLOOD ORDINANCES:
NATIONAL MODELS VS. LOCAL PROBLEMS

Maggy Hurchalla
Martin County, Florida

We are here today from mountains and beaches and swamps and big rivers. We have two things in common back home:
1) It floods.
2) We're growing.
I say the second with some confidence since where water is, people generally want to be. With some mosquito control, air conditioning, and affluence, everyone wants a puddle of their own.

In the fast-growing counties of Florida, our population doubles every ten years. If we figure out what to do right this year, we'll have only half the problem in ten years. If we don't figure it out, we will have three times the problem in 20 years. In figuring out what to do, many of us have been through the process of adopting a FEMA model "under the gun." Given a time deadline and the unthinkable penalty of loss of mortgage money, the process is stilted at best. With time, and the local will to do something, purely local solutions can be hung on the federal model ordinance for the best of both worlds.

While the federal model pays obeisance to the language and thoughts of Congress, it is mostly a hardware solution directed at the specific numbers of a specific study. And what's wrong with that? Surely it is better to base laws on engineering statistics than on undefinable whim. The problem is that the "engineering facts" are hard numbers, but not necessarily facts. There is simply not enough money, historical understanding, or scientific knowledge to do what FEMA tried to do for every square foot of America. For example, consider the following instances:

1) They left out the waves. Until last year the 100-year flood elevations in coastal areas reflected only still-water elevations. Storms don't so limit themselves.
2) They left out erosion. There are areas now in the ocean that were in B and C zones a few years ago.
3) They left out the creeks. Only major rivers were mapped.
4) They left out the swamps except in special cases.

In spite of all these "left outs," I would like to urge on you the conclusion that what is needed is not more money and more studies and more numbers. What is needed is a community perspective. Use the federal club and the FEMA model, but add local knowledge and local values. Community perspective allows you to be concerned with issues that voters and just folks understand. It deals only with the specific circumstances of the community, so mountain towns don't have to deal with beaches and vice versa. It deals with pieces of local geography and history that people know.

Local government is cheaper, faster, and closer than any other. Strange as it may seem, local government, if it chooses to be, is stronger when it comes to regulation than any other level. We tell people what they can do with property on a regular basis through building and zoning permits.

Given all those advantages, how can they best be used? I would suggest that the greatest failure of the federal direction is an unwillingness to use and enforce software solutions. The legislation, the rules, and the model ordinances deal with protection of dunes and mangrove, but not effectively. The whole program is built around water, but it does not deal very well with wetlands. Anyone who has managed flood plains over time knows that dunes and mangrove and wetlands are far more important than numbers. The ground truths of where the water is and where it goes will always be more accurate than computer models. Software solutions are the integration of land use and environmental regulation with flood plain management. They are based on obvious biological or planning principles instead of computer print-outs.

Let me mention one of the drawbacks of purely local action: lack of money. If a community perspective is to work, it must be cheap perspective. That limitation by itself assures that local solutions must look to regulatory standards that are more easily measured. Let's consider some examples.

By now everyone knows that sand dunes are important to prevent coastal flooding. The federal law says so, as well, yet I know of no case in Florida in which FEMA has exercised enforcement against local governments that allow damage to dunes. Except in the cleverer states and localities, almost everyone does some damage to the dunes. Florida is supposed to have a model setback
line, but some of the markers for that line are now out on the beach because of erosion. Florida no longer allows building on the beach itself, but there are still plenty of damaged dunes.

Without federal and state funds and vast and expensive studies, how can local government protect the dunes? It’s easier than you think—simply set lines. As long as the choice is rational, it is defensible. A good example would be requiring that all major structures be landward of the landward toe of the dune. There is plenty of information available and plenty of expert testimony that this is a rational choice in terms of flood protection, both for the individual structure and the health of the dune itself.

One of the ironies of the regulations would be that the FEMA V zone would no longer be buildable at all. It is important to remember that the line defining that zone on the official flood maps may be meaningless and even silly. Even with the waves added, our V zone elevation is only 12 feet for the one in 100-year storm. Every other year, however, waves come over the dune at 15 feet in fall northeasters. That being the case, it is rational to set back off the dune and to use a higher elevation. In the wizardry of computers and engineering "proof," we need to remember that the court’s standard for upholding legislative decisions is "fairly debatable" not "incomprehensible."

The beauty of using a topographic feature instead of a number is that it’s free. The ordinance can set the standard. The developer can be required to do a topographic survey as part of site plan approval in order to set the exact location. The same idea can be used to expand the mangrove protection section of the FEMA model. We set a line that protects all shoreline mangrove plus a 50-foot transition zone. The 50 feet did not come out of a computer, but was rational and defensible from an environmental standpoint as well as for flood protection.

Perhaps the best example of hardware versus software is in wetland protection. The FEMA model takes a purely mechanistic view of floodways that has to do with width and height and cubic feet per second. Anyone with the slightest local knowledge or biological training knows that the best way to stay dry is to stay out of swamps. Soils, vegetation, and other software indicators are good, cheap signs of wetness. Rather than measuring how wet it is, it makes good sense to stay out of wetlands completely.

Besides the environmental benefits, there are indirect benefits for flood control. Wetlands are more than a hydraulic chute for flood-carrying. The peat
soils that hold and store water are part of the natural flood prevention sys-
tem. The "isolated" wetlands are often important parts of river headwaters
that hold and slow peak flows.

If you are in one of those places where a new and growing populace is
dashing, lemming-like, towards the wet places, you need to move now. You
haven't the time or the money to use the FEMA approach on a detailed local
scale. You can use the FEMA framework and FEMA purpose. You can take the
federal club and make it into a sharp instrument for doing what you want to
locally.
THE SAN DIEGO COUNTY FLOODPLAIN MANAGEMENT PROGRAM

Joseph C. Hill
San Diego County, California

A. Jean Brown
State of California

Introduction

San Diego is one of the most rapidly growing areas in the United States. With virtually all the major rivers and streams in a natural (unchannelized) condition, a good flood plain management system is essential to prevent extensive construction of houses and other structures in floodway areas. The need for flood plain management was recognized more than 20 years ago. The California Department of Water Resources (DWR) provided the initial basis for flood plain management through their publication "San Diego County Flood Hazard Investigation, Bulletin 112, 1964" and related flood plain maps.

Several major private projects used Bulletin 112 as a basis for constructing golf courses in flood plains adjoining club houses, homes and other structures elevated above the 100-year flood level. Examples include: Carleton Hills Country Club on the San Diego River, Whispering Palms Country Club in the San Dieguito River and Pauma Valley Country Club in the San Luis Rey River.

San Diego County Flood Plain Program

In 1970, the County Board of Supervisors initiated a Flood Plain Mapping and Management Program which now includes the following elements.
Detailed Flood Plain/Flooding Maps

Some of the first flood plain floodway maps were developed by the State of California DWR for the Upper San Diego River. This is the most critical reach of river in terms of existing flood problems and regulation of development. The maps were published as part of the Upper San Diego River Flood Control Investigation, Bulletin 182, February 1976. This publication recommended Flood Plain Management as the most effective flood control option for the river. Part of the flood plain management program includes emergency procedures during flood periods. The DWR publication, "Stage-Discharge Relationships and Areas of Potential Inundation for Upper San Diego River (including a portion of San Vicente Creek) and Lower San Dieguito River, April 1976," provided detailed information to aid in emergency flood operations. The basis came from flood plain mapping material.

Criteria used in San Diego flood plain studies is given below:

- Orthophoto base maps (200 feet/inch scale). These maps have a picture quality which helps locate flood plain and floodway lines.
- Digitized cross sections. The accuracy of digitized points is better than one foot. Up to 99 can be used per cross section to provide a sufficient basis for development regulation.
- Floodways have specific boundaries. The floodway can be tied to the California coordinate system and property lines.

Examples of flood plain maps and plotted cross sections are given in Figures I and II.

Even with flood plain studies, which have much better quality than the FEMA studies, considerable opposition from property owners was experienced in the implementation of flood plain maps for zoning land development purpose.

County flood plain mapping and planning program began prior to implementation of the National Flood Insurance Program (NFIP). As Federal funds became available, the two programs were coordinated so that criteria and flood plain studies are compatible. The programs were also coordinated with the cities.
The following table provides a list of organizations that have participated in producing detailed flood plain studies that are currently used for planning and regulation of development.

<table>
<thead>
<tr>
<th>Organization</th>
<th>Distance (miles)</th>
</tr>
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<tbody>
<tr>
<td>State of California, Dept. of Water Resources*</td>
<td>20</td>
</tr>
<tr>
<td>Corps of Engineers*</td>
<td>90</td>
</tr>
<tr>
<td>County of San Diego</td>
<td>160</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>270</strong></td>
</tr>
</tbody>
</table>

*The County provided orthophoto base maps, digitized cross-sections and plotting of flood plain lines for all the detailed flood plain studies.

**Cost Effectiveness**

Use of flood plain maps to prevent construction of houses and other structures in flood plains avoids the need for construction of flood control channels. The table below provides the cost of flood plain mapping for comparison with the cost of three channel projects that are currently being planned or under construction in San Diego.

<table>
<thead>
<tr>
<th>Channel Costs</th>
<th>Cost (dollars/mile)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Los Coches Creek $7,000,000/2 miles</td>
<td>$3,500,000/mile</td>
</tr>
<tr>
<td>Telegraph Canyon Creek $5,400,000/1-1/2 miles</td>
<td>$3,600,000/mile</td>
</tr>
<tr>
<td>Sweetwater River $30,000,000/2 miles</td>
<td>$15,000,000/mile</td>
</tr>
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</table>
The cost of constructing channels is 350 to 1,500 times more than flood plain management in these examples. The three creeks and rivers listed above have flood plain/floodway maps which are used to prevent additional construction that would be damaged by a 100-year flood. However, so many houses and other structures are in the identified flood plain that channel construction is the only option available.

**Basis for Flood Control Design**

Proposed development in flood plains is aided by a flood plain study. Most of the information needed for design of bridges, channels and other structures is available, and the extent of potential flooding is defined. It is standard practice in San Diego County to use flood plain studies as a basis for design.

The most common type of development in flood plains is construction in the fringe area. This can be accomplished easily with practically no additional flood control engineering.

**National Flood Insurance Program**

The County of San Diego (unincorporated area) entered the Emergency Phase of the National Flood Insurance Program (NFIP) in 1971. Ordinances have been adjusted so they are in conformance with NFIP criteria. The County (unincorporated area) entered the Regular Phase of the NFIP in 1984.

**Planning**

The flood plain maps provide a basis for future planning and have been incorporated into the County General and Community Plan maps. They are also used in the zoning process by the County.

Community plans can specify special conditions relative to flood plains to reflect the desires of the citizens. Some communities elect to leave flood plains natural. Others use the flood plain maps, cross-sections, etc., as a basis for channel design.

**Environmental Considerations**

The County General Plan recommends that floodways be left in a natural condition unless existing structures are present, making channels desirable for safety
reasons. This approach is similar to that expressed by the Federal Government through Executive Orders 11988 and 11990.

**Erosion and Sedimentation Considerations**

In some locations, river beds are subject to extreme change during flood conditions. Lateral erosion during flooding can move a river several hundred feet outside the bank of a floodplain that has been defined with clearwater analytical methods. Sedimentation can raise a river bed—and the floodplain level—many feet above and beyond the clearwater floodplain. River lengths affected by major erosion and/or sedimentation is 10% to 20% in San Diego. While the percentage of river lengths is not great, the effect on property is. There are documented cases in which floods of 10-year and 50-year recurrence intervals have damaged structures and property outside existing floodplain boundaries.

A publication by the State of California, DWR has been helpful in evaluation problems. "Erosion and Sedimentation in San Diego County Watersheds" provided a basis for determining sediment yields from watersheds quantifying the increase in flood flows resulting from urbanization of a watershed and anticipating erosion and sedimentation in the San Diego River. This report predicted that major floods would put the 1,000 foot long Highway 67 bridge over the San Diego River in danger of failure. The 1978 and 1980 floods eroded the riverbed to the extent that the State replaced the entire bridge with a new structure.

Howard Chang, professor at San Diego State University and consultant, has developed procedures for evaluation of erosion and sedimentation in rivers. Several papers have been published in the American Society of Civil Engineers, Hydraulics Journal.

**Summary and Conclusion**

Rapid growth in an area with natural flood plains, such as San Diego, requires a comprehensive flood plain management program. Otherwise, houses and other structures will be constructed in unidentified flood plains, with danger to life and damage to structures as the inevitable floods occur in the area. Structural protection of houses and other buildings that are built in flood plains can be
expected to be 300 to 1,500 times more expensive than the cost of managing the flood plain.

Over 250 miles of flood plains have been mapped and are used for regulation of development in San Diego. The flood plain areas are identified in community planning maps. Environmental aspects of natural flood plains are incorporated in planning activities. The San Diego Program received an Outstanding Civil Engineering Achievement Award from the San Diego Section of the American Society of Civil Engineers in 1982.

The State of California, DWR was instrumental in initially identifying and providing the basis for directing development away from major flood plains. A coordinated effort between the State, federal and local government has provided an essential flood plain management program for San Diego.

References

State of California, Department of Water Resources

1964  San Diego County Flood Hazard Investigation, Bulletin No. 112

1976  Upper San Diego River Flood Control Investigation, Bulletin No. 182

1976  Stage-Discharge Relationships and Areas of Potential Inundation for Upper San Diego River (Including a Portion of San Vicente Creek) and Lower San Dieguito River in San Diego County

1977  Erosion and Sedimentation in San Diego County Watersheds
CHANNEL CHANGE IN SOUTHERN ARIZONA--
IMPLICATIONS FOR FLOODPLAIN MANAGEMENT

Marie S. Pearthree
Pima County Department of Transportation
and Flood Control District

Frequent changes in morphology and position of alluvial channels of ephemeral streams create uncertainties for floodplain management in the semi-arid southwestern United States. Federal floodplain management regulations, which form the basis for local floodplain management, are primarily concerned with overbank flooding. In the Southwest, however, channel bank erosion and lateral channel migration often present hazards of equal or greater magnitude than overbank flooding, yet they are not adequately addressed in the federal regulations nor often brought to the attention of communities enacting floodplain management programs. Frequent channel changes also lead to erroneous flood hazard delineation, when it is based on standard engineering procedures that utilize rigid channel boundary models. Instability of channel configurations leads to variability in the areal extent of inundation during the 100-year and lesser floods.

This study documents channel change along an alluvial stream system and presents steps taken by one community to regulate urban development adjacent to such stream systems. The Rillito Creek system of Pima County, Arizona, consisting of Rillito Creek and major tributaries Pantano Wash and Tanque Verde Creek, was chosen for study because of severe channel bank erosion in recent years within the rapidly expanding Tucson metropolitan area. Encroachment of urban development onto the floodplains of this stream system has resulted in widespread erosional damage to public facilities, commercial/industrial structures, and private residences.

The Rillito Creek system drains approximately 934 square miles (2419 square kilometers) of southeastern Arizona (see Figure 1). The watershed consists of large lowland areas surrounded by mountains, with elevations ranging from 2200 feet (690 m) to 9450 feet (2880 m). Vegetal cover varies from the Sonoran Desert communities of creosote bush, desert saltbush, and cacti in the lower-lying basin and foothill areas, to evergreen forest at the
FIGURE 1. Map of the Rillito Creek watershed.
highest elevations (Schwalen, 1942; Turner, 1974). Mean annual precipitation increases with elevation, ranging from approximately 10.5 inches (267 mm) to 37.5 inches (953 mm) (Grove, 1962).

There is usually rainfall during two distinct seasons, summer and winter, separated by dry periods. Summer storms typically consist of thunderstorms of limited areal extent that result from surges of moist tropical air from the Gulf of Mexico and the Pacific Ocean (Durrenberger and Wood, 1979; Sellers and Hill, 1974). Winter rainfall, which tends to cover larger areas and be of longer duration, originates from low-pressure systems and cyclonic storms from the Pacific Ocean. Remnants of tropical storms also drift northward into Arizona in August, September, and early October, and occasionally produce large amounts of precipitation and sizable floods (Durrenberger and Wood, 1979).

Streamflow Characteristics

As in all semiarid regions, streamflow in the Rillito Creek system is extremely variable, due primarily to differences in watershed topography and to the temporal and spatial distribution of rainfall. Annual peak flow records are generally dominated by low flows with a few years of high flows (see Figure 2).

At least two distinct flow regimes are present in the Rillito Creek system. Summer flows are characterized by high peak discharges and short durations. Winter flows are usually of lower peak discharge but longer duration. Pantano Wash flows primarily in response to intense local summer thunderstorms and carries sediment loads consisting mainly of fine grain sizes from the large sedimentary basin areas that it drains (Saarinen et al., 1984). In contrast, Tanque Verde Creek conveys more winter flow that includes snowmelt runoff and coarser sediment sizes from the predominantly mountainous areas of its watershed. The more equitable distribution of summer and winter flow and coarse sand load of Rillito Creek are the result of the combined contributions of the Pantano Wash and Tanque Verde Creek drainages. Extreme flow events resulting from summer tropical storms or extended periods of heavy winter precipitation, typified by high peak discharges, prolonged durations, and high sediment loads, may constitute a third flow regime (Keith, 1981).

Historical Channel Change

Channel change within the Rillito Creek system since 1941 has been characterized by prolonged periods of channel narrowing interrupted by abrupt episodes of locally severe channel bank erosion and general channel widening.
FIGURE 2. Variations in the mean and median widths of Rillito Creek from 1941 to late 1979 (upper graph) correlated with annual peak flows recorded at the Rillito Creek near Tucson gauging station (lower graph).

(Pearthree, 1982). Aerial photographs taken from 1941 through 1983 were utilized to investigate historical channel change in addition to longitudinal streambed profiles, annual peak flow records, climatic records, and historical observations. Variability of channel width along this stream system from 1941 to late 1979 is summarized in Table 1, and Figure 2 illustrates the correlation between directions of change in channel width and magnitudes of streamflow for the same time period.

Rillito Creek, Pantano Wash, and Tanque Verde Creek consist of wide sandy channels with near-vertical banks cut into alluvium. Channel bank heights increase progressively in the downstream direction to as much as 15 feet (4.6 m). The present channel system began to evolve in the late 1800's and early
Table 1. Variations in mean and median channel width and standard deviation, from 1941 to 1979, of Tanque Verde Creek (a), Rillito Creek (b), and Pantano Wash (c). Channel width was measured at 22 cross-section locations along Tanque Verde Creek, 35 along Rillito Creek, and 31 along Pantano Wash.

(a)

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(b)

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(c)

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<td>1979</td>
<td>280</td>
<td>85</td>
<td>271</td>
<td>83</td>
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1900's when arroyo-cutting prevalent throughout the Southwest initiated channel entrenchment (Cooke and Reeves, 1976). Prior to 1941, the Rillito Creek system exhibited braided channel patterns resulting from extended periods of drought followed by one or more wet years (see Figure 3). Between 1941 and the early 1960's, single channel patterns developed in response to low-magnitude summer flows.

In the early 1960's, the behavior of Pantano Wash began to diverge from that of Rillito Creek and Tanque Verde Creek. From 1963 to late 1979, Pantano Wash steadily incised as the channel narrowed and the streambed degraded. Mean channel width decreased from approximately 570 feet (173 m) to 280 feet (85 m), and the streambed dropped locally as much as 12 feet (3.7 m). However, severe local channel bank erosion ranging up to 375 feet (114 m), produced by occasional meandering low and by significant flow events in 1958, 1970, and 1971, accompanied this narrowing trend.

In contrast, Tanque Verde Creek and Rillito Creek have widened and narrowed in cyclical fashion (Figure 3). In December, 1965, the fourth storm in a series of five consecutive winter storms produced a flow event with an estimated recurrence interval of 27 years in Tanque Verde Creek and 16 years in Rillito Creek (Aldridge, 1970). Runoff was augmented by snowmelt from the higher elevations of the watershed. Extreme channel bank erosion ranging up to 680 feet (107 m) occurred along both stream channels in conjunction with general channel widening (Figures 3 and 4), resulting in 1.25 million dollars in damages (Arizona Daily Star, 1965). The largest increases in channel width were produced by erosion of the concave banks of channel bends, which migrated in the downstream direction. Following this event, many of the eroded areas recovered naturally through sediment deposition and growth of vegetation or were reconstructed artificially with fill material and bank stabilization measures such as rock riprap and wire fence revetments.

In December of 1978, Rillito Creek and Tanque Verde Creek once again widened extensively (see both Figure 2 and Table 1). As in 1965, a winter storm over the Tanque Verde Creek watershed produced streamflow that included snowmelt. Little sediment was readily available for transport within the channels, having been removed by previous flow in March, 1978 (T. Maddock, Jr., University of Arizona, written communication, 1980). As a result, this flow eroded up to 190 feet (57 m) of the channel banks, and the streambed of Rillito Creek aggraded locally as much as 7.5 feet (2.3 m). The recurrence interval of this event was estimated at 22 to 24 years in Tanque Verde Creek and 20 years in Rillito Creek (B.A. Aldridge, U.S. Geological Survey, verbal communication, 1981). Channel recovery and reconstruction also followed this event.
FIGURE 3. Channel change along Rillito Creek from 1941 to 1983 downstream of the confluence of Pantano Wash and Tanque Verde Creek from Craycroft Road to Swan Road. Note the change in plan-view pattern from 1941 to 1963. Extreme channel bank erosion resulting from the December, 1965 flow event is shown in the 1967 photograph. The 1978 photograph shows a smooth channel alignment produced by channel excavation and protection of the banks primarily with wired rock riprap, which failed in the October, 1983 flood event.
On October 1 and 2, 1983, the most severe channel bank erosion and lateral channel migration seen to date along the Rillito Creek system was produced by a flow event provisionally estimated to have a recurrence interval between 50 and 100 years in Rillito Creek, 10 to 25 years in Pantano Wash, and 10 to 50 years in Tanque Verde Creek (Hjalmar Hjalmarson, U.S. Geological Survey, verbal communication, 1985). Between September 28 and October 2, southeastern Arizona received 6.7 to 10.5 inches (170 to 267 mm) of rainfall produced by a surge of tropical moisture that traveled northeastward from the Pacific Ocean off the coast of Baja, California (Saarinen et al., 1984). Bank erosion was the most severe hazard produced along the more incised stream channel reaches (see Figure 3), although some overbank inundation also occurred. As described by Baker (1984), the Rillito Creek system displayed channel bank erosion that followed existing meander patterns and alternated between stream banks, as allowed by bank protection (Figures 5 and 6). Severe bank erosion also occurred at the downstream terminus of protected channel banks along Rillito Creek, implying that non-continuous bank stabilization measures locally concentrate bank erosion as well as protect channel banks and adjacent structures.

Many of the effects of the October, 1983 flood repeated the experiences of the 1965 and 1978 events. In eastern Pima County, approximately 28 bridges, nine flood control projects, and numerous residential, commercial, and industrial developments were damaged by channel bank erosion (Pima County Department of Transportation and Flood Control District, 1985). Power lines were damaged when their support pads were undermined by channel bank erosion or streambed scour, and major utilities were washed out (Saarinen et al., 1984). Erosional damage also occurred at several active and abandoned sanitary landfill sites and at wastewater treatment facilities. The total cost of the flood repair and flood hazard mitigation program prepared by the Pima County Department of Transportation and Flood Control District following this event has been estimated at $105.8 million.

Channel changes observed along the Rillito Creek system are consistent with long-term characteristics of southwestern stream systems (Saarinen et al., 1984). The greatest amounts of bank erosion documented in this study have occurred on the concave banks of channel bends, along unprotected banks where flow has been concentrated by upstream bank stabilization, and at locations where the silt-clay content of the banks and density of riparian vegetation have been minimal (Pearthree, 1982). Lowering of the groundwater table in this century has virtually eliminated riparian vegetation along the middle and lower
FIGURE 5. Damage to the northern (left) abutment of the Dodge Road bridge across Rillito Creek caused by channel bank erosion and lateral channel migration in October, 1983. Note the threat to the electric utility station on the opposite bank downstream. Photograph by Peter Kresan.
FIGURE 6. Damage to the Pima Park Townhomes caused by lateral migration of a prominent meander bend of Rillito Creek. Erosion occurred behind the soil cement bank protection shown adjacent to the townhomes, leading to its failure. Photograph by Peter Kresan.
reaches of Rillito Creek, rendering the channel banks less resistant to erosion. Local sand and gravel operations have also been linked to channel changes by initiating 1) channel bed degradation upstream of excavations, 2) bank sloughing in conjunction with head-cutting upstream of in-channel and overbank operations and from upstream sediment trapping, and 3) bank erosion caused by diversionary structures related to the operations.

Floodplain Management

In compliance with federal regulations under the National Flood Insurance Program, management of floodplains in Pima County has focused on areas potentially subject to inundation by the 100-year flood, defined as having a 1% chance of occurring in any given year. The geomorphic complexity of alluvial stream systems in the Southwest, as illustrated in this study, creates difficulties in administration of federal regulations that are based primarily on flooding. Abrupt channel change, including fluctuations in cross-sectional channel shapes, plan-view patterns, and channel positions, has generally constituted a greater hazard to Pima County than has overbank flooding.

Recognition of the threat to the public safety and welfare posed by such channel change has led Pima County to establish building setback requirements for structures from unstabilized channel banks and to begin delineating erosion hazard zones along major watercourses for regulatory purposes.

Much of the damage in Pima County caused by channel bank erosion has been to public and private facilities constructed prior to the establishment of building setback distances. Since 1974, when the first Pima County floodplain management ordinance was adopted by the community, building setback distances along the major watercourses have evolved from 100 feet (30 m) for commercial/industrial structures and residential structures for rent and 300 feet (91 m) for owner-occupied residences, to 500 feet (152 m) for all structures. The latter distance was adopted following the October, 1983 flood.

At this time, the minimum building setback distance of 500 feet (152 m) is required along the Rillito Creek system and other major watercourses in Pima County where no unusual conditions exist. Where unusual conditions do exist, including historical meandering of the watercourse, presence of sand and gravel operations, poorly defined or unconsolidated channel banks, or local changes in directions, quantities or velocities of flow, building setback limits are to be
established on a case-by-case basis by the County Engineer. Setback distances ranging from 50 to 250 feet (15 to 76 m) have also been established along smaller watercourses based on the magnitude of the estimated 100-year peak discharge.

Along the Santa Cruz River, to which Rillito Creek is tributary (Figure 1), preliminary erosion hazard boundary maps have been compiled based on qualitative and quantitative analyses of channel bank erosion and lateral channel migration (see Figure 7). These analyses have included investigations of historical channel positions and erosional sites seen on aerial photographs, and have considered present channel patterns, locations of sand and gravel operations, landfill sites, and existing and planned bank stabilization measures. When adopted by the Pima County Floodplain Management Board, these maps will be used to restrain urban development within zones determined to have a high potential short-term and long-term channel bank erosion and lateral channel migration. Where erosion hazard limits exceed mapped floodway and 100-year floodplain limits, the erosion hazard limits will form the basis for regulating development adjacent to the stream channels, as these represent estimated worst possible flooding and erosional conditions.

Conclusions

Floodplain management practices that account for the geomorphic complexity of alluvial channels of ephemeral streams will continue to evolve in the Southwest as it is increasingly recognized that semiarid stream systems do not lend themselves to flood hazard regulatory procedures established at the national level. These procedures are incomplete when they fail to account for channel change. Nonstructural floodplain management approaches are recommended to regulate urban development adjacent to these stream channels. The high cost of bank stabilization measures capable of withstanding local streamflow erosional conditions, such as soil cement at approximately one million dollars per mile, discourages implementation of structural flood and erosional control measures on a large scale. Nonstructural floodplain management approaches can save the cost of channel bank stabilization as well as decrease the potential for erosional and flood damages. Through geomorphic research, the complex behavior of alluvial stream systems in the Southwest can be documented, thus providing the data necessary to locally augment federal floodplain management regulations and policies to suit the Southwest.
FIGURE 7. Erosion hazard boundary map for the Santa Cruz River at its confluence with Rillito Creek.
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<thead>
<tr>
<th>Author(s)</th>
<th>Title</th>
<th>Year</th>
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<td>Floods of November 1965 to January 1966 in the Gila River Basin, Arizona and New Mexico, and Adjacent Basins in Arizona.</td>
<td>1970</td>
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Typically when one thinks in terms of problems/damages due to high water levels along a river reach the association is to a set of flood flow rates which caused such water levels. Recognizing that flood flows are of a variable size from time to time, a statistical analysis is performed on historic data in an attempt to associate expectancy or probability of occurrence with differing flood size (i.e., the 100-year flood is 10,000 cfs). These flows are then converted to associated river levels to explore potential damages and the effects and economies of various mitigations measures.

There are, however, other factors which may exist which have an effect on river level as well as the size of the flow rate. Certainly engineering works and encroachments on the flood plain may have a local hydraulic influence which alters previously existing relationships between flood size and associated river level. Such hydraulic influence may also exist on reaches of rivers which experience an ice cover and this paper addresses one aspect of this possibility.

River Levels and Ice

There are a number of situations which can develop from time to time and place to place on any given river system which effect river stage. Probably the most commonly referred to is the so called "Ice Jam". While this condition has been researched to a limited extent and several papers published there is still much that is unknown or uncertain. For the time being we will leave this area to others and concentrate our discussion on river level responses that may occur during the period associated with river freeze up and a later period which we will call the period of "stable ice control".
When a river reach begins to develop an ice cover an additional boundary is created (the ice cover) which increases the resistance to flow. This increased resistance causes the flow to be retarded and the depth to increase. The river level will also increase further due to buoyant effects as the ice cover thickens. There is also an additional hydraulic effect which takes place during freeze up due to the unsteady nature of the flow.

The analytics and mechanics of the items mentioned above may be found in papers by the authors. (See list of references).

Given the right set of circumstances the analytics suggest that river depth could increase with an ice cover by over thirty percent due to the ice resistance alone.

Many reaches of northern rivers form an ice cover in parts of the reach in the early winter and not in others. This allows for the production of frazil ice (fine spicule, plate or discoid ice crystals in super cooled turbulent waters) in the open water sections. Frazil ice tends to collect in the slower moving sections under existing downstream ice cover. These deposits can become quite large and act as an encroachment into the river cross section. This in turn can cause a "backwater" effect upstream of this "ice control" which increases the opportunity to form additional ice cover as the backwater deepens and slows the upstream flow. This, of course, also decreases the surface area available for the formation of additional frazil ice. Thus, in this type of situation, there is a progressive development of the ice cover in an upstream direction from the slower moving sections toward the faster zones. This is the freeze up period and once complete is followed by the period of stable ice control until such time as breakup occurs. The freeze up period generally lasts several days and the period of stable ice control may last for months. The combination of this backwater effect with the added resistance to flow and attendant buoyant displacement can cause rather large river level increases which can last for long periods of time.

Some Examples

In the course of pursuing a research effort dealing with the hydraulics of ice covered rivers in cooperation with the U.S. Geological Survey and U.S. Army Cold Regions Research and Engineering Laboratory the authors have had the opportunity to
review published and unpublished data of the U.S. Geological Survey. This has uncovered numerous examples of the situations described above.

One such case is the U.S. Geological Survey gage located on the Brule River near Florence, WI. The gage has been in place for over 40 years and the flood of record is 4700 cfs. A log pearson type III analysis indicates this flood would be approximately the 100 year flood. Unpublished data for this gage indicates that almost every winter during the freeze up period river levels exceed that corresponding to the flood of record even though flow rates are relatively small. Further, during the period of stable ice control (about four months), water levels are such as to be indicative of 25 year flood levels (about 3000 cfs) even though the actual under ice flow is only 300 to 400 cfs. The conventional type of flood analysis applied to this gage history would in effect be working on a problem that doesn't exist.

Another example is the Lookingglass River near Eagle, Michigan. The flood of record is 2,860 cfs with a gage height of 7.70 ft. This would correspond to about the 100 year flood. The gage height corresponding to bank full stage is approximately 6 ft. Certainly this flood did cause some overbank flooding. A closer look at the record for this station indicates water levels are often over the 6 ft. gage height due to backwater from ice. In fact in 1956 gage height was 9.9 ft. from ice backwater which would correspond to something like the 10,000 year flood.

There are numerous other examples that one could site which are not so spectacular. These might be summed up by stating that it is not uncommon to find river levels with an ice cover which are indicative of the 10 to 20 year flood levels even though actual flow rates are relatively small. There were also several streams where backwater from ice caused the maximum water level in any given year.

Where Are We?

The previous section indicates that there is recorded evidence of ice related effects relative to abnormally high water levels. One should keep in mind that these exist only because the U.S. Geological Survey happened to have a gage at the right place to have recorded such effects. Certainly many more locations must exist on these river systems; there simply is no "formal" record.

A report to the National Science Foundation by the Illinois State Water Survey discusses a number of critical research needs relative to flood mitigation. In the section dealing with Hydrology and Hydraulics nine recommendations were listed for
critical research. Four of the nine involve reliable predictions of water levels with appropriate related probability. These would include topics such as probability at ungaged locations, appropriate probability distributions, predicting stages from given flow rates and defining flood plain boundaries for various levels of probability.

There has been little research activity in these areas, relative to the effects of an ice cover, and much that does exist is very recent. We do feel at this time that there is reasonable evidence to suggest that the magnitude of the ice/water level effect is site (reach) specific and that collection and analysis of certain summer and winter data in the reach can be used to define coefficients for the reach which can be used in a predictive model. Such research is presently under way on three Michigan rivers with the present goal of establishing a predictive model for at least the period of stable ice control.

**Summary and Conclusions**

It should be evident that on certain reaches of ice covered rivers flood analysis should include statistical analysis of water levels caused by ice, especially for the more frequent events (say 10 to 20 years). This area should also be addressed from a design and planning point of view. For example, the design of a road/stream crossing (culvert) requires use of "water levels" with various expectancy (not necessarily flows with certain expectancy). Another example might be in assessing the effects of engineering works along the river and flood plain as they may effect future locations of "ice controls" and "frazil ice generators". These locations and the length of time a "frazil ice generator" are operative will dictate expected ice related river levels.

There is still much to do and to learn concerning the hydraulics of ice covered rivers. It is expected that research at Michigan Technological University will continue to address these problems in the future and that better analytical techniques and predictive capability will be developed.
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Wiitala, S. W.
MANAGEMENT OF FLOODPLAIN SAND AND GRAVEL MINING

Joann Mossa
Louisiana Geological Survey

Introduction

Conflicting interests and issues surround the practice of floodplain sand and gravel mining. Because existing federal and state regulations fail to recognize several problems that are peculiar to floodplain operations, management which recognizes both environmental and industrial needs should be developed. In Louisiana, consequences from the lack of such policy are manifest and continue to intensify. Early assessment of the concerns expressed by the various users of floodplain resources is the first step toward balancing these diverse interests through management.

Regulations Affecting Sand and Gravel Mining

Several complex issues and problems pertaining to floodplain mining operations are often not addressed by federal, state, and local regulations. An overview of current regulations is required to understand the needs and concerns represented by diverse public interests. Gaps in representation can then be addressed by modifying existing legislation or by drafting new legislation if none exists.

No federal law directly regulates the sand and gravel mining industry (Banks and others, 1981). Some federal laws, however, may indirectly affect mining practices (Table 1). For example, in-stream mining could be affected by Section 404 of the Federal Water Pollution Control Act, which regulates the dredging and filling of navigable waters.

Most of the responsibility and authority for regulating sand and gravel mining is left to state and local government. About 30 states currently have laws affecting sand and gravel mining operations or reclamation (Fig. 1). Reclamation refers to the procedures, such as backfilling, landscaping, and revegetation, undertaken to achieve the land use desired after mining. Such requirements may vary considerably from place to place. Some states allow local jurisdiction to take precedence in
Table 1. Federal laws indirectly affecting surface mining (from Banks and others, 1981).

<table>
<thead>
<tr>
<th>Clean Air Act</th>
<th>Wild and Scenic Rivers Act</th>
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<td>Federal Land Policy and Management Act</td>
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<td>Fish and Wildlife Coordination Act</td>
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<tr>
<td>Surface Mining Control and Reclamation Act</td>
<td>Mine Safety and Health Act</td>
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(coal only)

Figure 1. States with laws affecting sand and gravel mining operations or reclamation.
regulating operations whereas other states maintain the right to approve final mining permits (Banks and others, 1981). In addition, sand and gravel operations may be governed by local zoning ordinances, permits, plans, and variances.

Because the governing regulations cover a wide range of mineral extraction techniques, geographic settings, and commodities, floodplain sand and gravel mining practices are not often addressed in legislation. Issues other than operation and reclamation, such as industrial and environmental concerns, are often disregarded. States which lack mining policy, as exemplified by Louisiana, are more likely to experience greater environmental damage.

Issues of Floodplain Sand and Gravel Mining

Sand and gravel are vital commodities for urban growth and infrastructure, especially where hard rock aggregate is scarce. Public interests are best served if these minerals can be extracted at minimum cost with minimal environmental damage. Mineral conservation for the future and benefits to the local economy are also important considerations in planning. Management should attempt to balance the production and conservation of minerals while minimizing environmental, social, and other negative impacts associated with mining.

Environmental impacts associated with sand and gravel mining are probably the least significant compared to those associated with other types of surface mining, yet several problems may still develop. Channel instability and impacts on flood rates and patterns are two potential problems associated with mining operations in floodplains. Increased bank erosion and changing channel position and gradient may affect property and structures, causing legal problems regarding ownership, engineering liability, mining, and water rights. Stream aggradation resulting from the overloading of detritus, which increases flood stages and the amount of land being inundated, was described in early studies (Gilbert, 1917). Conversely, degradation attributable to several possible causes has also been observed (Scott, 1973; Bull and Scott, 1974; Graf, 1979; Lagasse and others, 1981; Storm, 1982). Gravel mining activities may also disturb water quality and floodplain habitat, thus affecting water resources, fisheries, and wildlife. Consequently, several problems unique to floodplain mining need to be incorporated into management plans in addition to reclamation.
Concerns in Louisiana

Because of economic considerations and limited construction materials, most gravel mining in Louisiana is confined to the valleys of rivers that transport coarse material. This presents problems regarding both economics and environment. For example, inundation of resources by dam construction must be considered an economic loss for local expanding urban areas. In addition, mining practices should attempt to minimize environmental impacts to the channel and floodplain. Several problems that are manifest in Louisiana reflect the failure to consider the dynamic nature of rivers, particularly when floodplain vegetation and character is disturbed.

Changes in channel morphology have been observed since the initiation of floodplain gravel mining in the Amite River in southeastern Louisiana (Fig. 2). Some changes are due to indirect effects of gravel mining, after floodwaters have reworked the alluvial valley. Removal of riparian vegetation and mining of point bars reduce the resistance of river banks to erosion during floods (Fig. 3). Also, during high stages, breaching and channel diversion into adjacent gravel pits may occur, especially where banks are not stabilized by vegetation. This results in a local change in base level, which influences aggradation and degradation patterns. Through these processes, channel pattern and meander geometry have been altered significantly after major floods (Mossa, 1983).

Direct environmental damages may also result from increases in sediment flux and channel dredging associated with in-stream mining. Concomitant hydrologic changes occur as the channel is shortened, widened, and altered in gradient; these changes may have aggravated local flooding on the Amite River in recent years (Mossa, 1983).

Although recognition of the adverse effects of floodplain mining is still in the early stages, practices causing the most severe environmental damage should be minimized. Removal of riparian vegetation and the mining of point bars and channel bottoms should be avoided, and buffer zones next to the channel should be established. Other guidelines developed for mining gravel in floodplains in arctic and subarctic regions (Joyce and others, 1980) may be applicable to rivers in Louisiana and elsewhere.
Figure 2. Historic channel positions of the middle Amite River show changes in the meander and channel geometry and an overall decrease in sinuosity through time. Channel diversion into the large pit north of Grangeville changed base level and is one factor that resulted in channel adjustment.
Figure 3. Removal of riparian vegetation and mining of the point bars and floodplains reduce the resistance of the banks during floods. Changes, including increased width, meander cutoffs, abandoned point bars, and an increased number of midchannel bars, have developed since the initiation of mining near Dennis Mills on the Amite River.

Minimal environmental damage and additional land use benefits are achieved with reclamation, which is particularly important near river channels where sediments and talus piles may be reworked in subsequent floods. These efforts are most successful if they are integrated into the total mining operation from the beginning and directed toward a desired post-mining land use (Dunn, 1982). Although this has not been the case in Louisiana, remaining landscapes can be left in a stabilized, non-hazardous, and useful condition if some planning measures are taken. Such plans should be developed promptly in states with severe flooding problems but no reclamation regulations, such as Louisiana.

Once a river has changed its pattern and form, the problem becomes much more difficult to resolve. Whether reclamation should go beyond sculpturing and revegetating the floodplain and attempt to restore the previous channel character is a question that requires consideration. Although time will probably allow the river
to restore itself, rivers are dynamic and little is known about how rapid or effective these modifications will be. Aggravated flood conditions could persist for years and intensify if unregulated mining continues. Establishing management guidelines prior to intensive mining is the better approach to minimizing environmental impacts.

Management should also encourage the sand and gravel industry to provide planning input to balance various local and regional, short- and long-term goals. Information regarding resource distribution should be provided to concentrate mining in preferable locations. Guidance and recommendations to facilitate reclamation should be given at the local and state level. The continued availability of resources depends upon the cooperation of the industry, whose input in decision-making and issues is important to balancing diverse economic and environmental interests.

Conclusions

Mitigation of impacts and restoration of mined landscapes in floodplains may entail either management or engineering measures or some combination of the two. Although some measures will result in a direct and noticeable improvement of the environment, others may take several years to produce visible results, and in some cases, time may be the only solution to recovery. The recommendations stated here and the guidelines developed for mining in other floodplains should be considered prior to mining because environmental problems become much more complicated and harder to resolve after mining operations have begun. Floodplain managers can help to balance diverse interests by considering input from various sectors early in the decision-making process. In states without legislation, such as Louisiana, floodplain management may be the most immediate solution to addressing environmental and industrial interests.

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Storm, D.
LOCAL FLOOD WARNING SYSTEMS -- WHERE ARE WE?

Curtis B. Barrett
National Weather Service

Common sense suggest that people vulnerable to floods ought to be warned so that response can be taken to protect lives and property. The National Weather Service is responsible for warning individuals of approaching floods. Generally, for rivers which crest greater that 18 hours after rainfall occurs, the conventional flood forecast operations of the National Weather Service provide timely and accurate flood forecast service for threatened communities. In rivers which crest less than 18 hours after rainfall occurs, time is short, data is scarce, and development of timely, accurate and specific flood predictions is difficult, if not impossible. One solution to this short-fused flood problem is the development of an integrated local flood warning and response system for a community vulnerable to floods.

Recently, the Federal Interagency Work Group on Local Flood Warning Systems has produced a report titled, "Guidelines on Local Flood Warning and Response Systems for Communities." This document defines a local flood warning system to consist of four steps. These four steps include: 1) Data Collection; 2) Data Transmission; 3) Flood Forecast; and 4) Inform Local Officials. These four basic steps offer the threatened community recognition of the magnitude and extent of the flood threat. However, providing a timely and accurate warning will not reduce flood losses unless an effective response system is in place. A flood warning is useless unless people know what actions to taken when they receive the warning. The response system consists of three steps: first, warn local residents who will be affected by the flood; second, threatened residents should be evacuated; and the last step is re-renchy, or return of residents into the flood plain.

Local flood warning systems are flood recognition or forecast systems that determine the magnitude and extent of flooding. These systems are categorized as manual or automatic. Manual systems primarily consist of volunteer observers who read plastic rain gages, a volunteer community flash flood coordinator, and a simple flood forecast procedure provided by the National Weather Service. Most local flood warning systems are manual systems and are quite effective in providing basic flood
recognition. Automated systems consist of a volunteer community flash flood coordinator, automatic self-reporting hydrologic sensors, radio transmission and receiving equipment, a continuously operating microprocessor, river and rainfall data analysis software, and a hydrologic simulation model. The National Weather Service and/or private hydrologic consulting companies provide hydrologic expertise in providing automated local flood warning systems to communities.

There are basically three types of automated local flood warning systems in operation. These systems vary in functional capability and cost. The flash flood alarm gage, the most basic type, consists of water level sensors connected to an alarm or light located at a community agency which operates 24 hours a day. River stages exceeding a pre-set level trigger the alarm. The distance the alarm is located upstream from the community determines the amount of warning time available. There are approximately 65 flash flood alarm gages in operation around the country. The flash flood alarm gage provides the least capability of all the automated systems and is also the least expensive.

The Automated Local Evaluation in Real Time (ALERT) system is an automated local flood warning system developed by hydrologists at the NWS California/Nevada River Forecast Center. The ALERT system has rapidly gained popularity in the United States with about 50 communities now operating or installing these systems. ALERT consists of automatic reporting river and rainfall gages, a radio communications system and a base station consisting of radio receiving equipment and a microprocessor. Various types of software are available for the ALERT system from data analysis software to hydrologic forecast model. Basic software is available from the NWS, while more special-needs software is available through private firms.

In a 6-state region of Appalachia, the Integrated Flood Observing and Warning System (IFLOWS) is implementing an automated prototype networked local flood warning system that links the county emergency operations center (EOC) to the state EOC and to the NWS forecast office. Over 100 counties will be operating nearly 600 automatic reporting rain gages to 100 county-based stations (radio communication, receiving equipment, DEC microcomputers which collect, display and relay rainfall data and flood warning information). The IFLOWS program uniquely distributes flood related information to Federal, State, and local offices.
Local Flood Warning System Standards

The NWS Technical Working Group on Local Flood Warning Systems (LFWS) has developed standards for automated local flood warning systems. These standards are currently under review by the NWS and will then be sent to all interested Federal agencies for review. The Hydrology Subcommittee of the Interagency Advisory Committee on Water Data is investigating the need for a standing committee on local flood warning systems to address LFWS problems and issues and to continue modification of LFWS standards as technology continues to advance. The purpose of establishing LFWS standards are:

1) To ensure that basic flood forecast capability is made available to communities ranging from poor and technically unsophisticated, to wealthy and professionally talented.

2) To ensure that LFWS data can be made available to all NWS Offices responsible for flood warnings. This assures coordination which is vital to warning the population of a flood event.

3) To promote competition between private sector firms who wish to develop "enhanced" LFWS software.

We anticipate LFWS standards will be available in late summer for distribution to communities.

Where are We Going?

As the proliferation of LFWS continues, various issues begin to surface concerning the type and distribution of data and forecasts. As more and more communities continue to install automated systems, a high volume data base will be created. If an upstream community develops an automated flood warning system, who is responsible to warn the next downstream community-based, or the upstream community system operation? What Federal, State, and local agencies require LFWS data? What specific data?
The NWS is developing a project known as FLASH (Flood Local Analysis System for Hydrometeorology) which will provide the Weather Service Forecast Office (WSFO) with two basic capabilities. The first capability is to establish a hydrometeorology data base which will contain up-to-date river and precipitation data (including automated LFWS data), and secondly, simplified hydrologic models to provide site-specific forecasts for flash-flood-prone communities.
UTILIZATION OF THE SEA, LAKE AND OVERLAND
SURGES FROM HURRICANES (SLOSH) MODEL
IN HURRICANE EVACUATION STUDIES

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Introduction

The coastal population of the United States has increased sharply over the past twenty years and in many locations the rate of growth has accelerated. This tremendous growth and development has presented emergency management officials with the difficult task of developing hurricane evacuation plans which can reasonably assure safe and effective hurricane evacuations for the vulnerable population. The critical data necessary for the development of these plans often require comprehensive and specialized analyses. In an effort to assist state and local governments develop the needed technical information, the U. S. Army Corps of Engineers, Federal Emergency Management Agency and the National Oceanic and Atmospheric Administration have joined state and local emergency management agencies in conducting hurricane evacuation studies for certain Gulf and Atlantic coastal basins. These studies consist of several related analyses to develop technical data concerning hurricane hazards, vulnerability, public response, timing of evacuations and sheltering needs for various hurricane threat situations.

The hazards analysis quantifies the still-water surge heights, waves and windspeeds for various categories, tracks, directions and forward speeds of hurricanes considered to have a reasonable probability of striking a particular coastal basin. Potential freshwater flooding from rainfall accompanying hurricanes is also considered; however, due to the wide variation in amounts and times of occurrence from one hurricane to another, rainfall can only be addressed in general terms. The purpose of this manuscript is to describe the utilization of the Sea,
Lake and Overland Surges from Hurricanes (SLOSH) Model in the hazards analysis of hurricane evacuation studies.

Hazards Analysis

The Sea, Lake and Overland Surges from Hurricanes (SLOSH) numerical model, developed by the National Weather Service, is commonly utilized in the hazards analysis of hurricane evacuation studies to determine the still-water surge heights and windspeeds associated with various simulated hurricanes modeled for a study. Developed for selected Gulf and Atlantic coastal basins, the SLOSH model incorporates a curvilinear polar coordinate grid scheme (a fan-shaped grid) in which a basin's bathymetry, topography and natural and man-made barriers are mathematically represented. The grid configuration of the model has a resolution of approximately one-half square mile for inland areas at the focus to 1 1/2 square miles at the coastline. The grid squares become progressively larger as the grids extend outward from the coastline where storm effects are of secondary interest.

Other computer models have reliably calculated surge heights for the open coastline; however, the SLOSH model has the added capability to simulate the routing of storm surge into bays, estuaries, coastal rivers and overland. Significant natural and man-made barriers such as dunes, roadbeds or levees are also represented in the model and their effects considered in the calculations of surge heights for a location. This capability results in more accurate and realistic simulations of the impacts an area can expect from potential hurricanes. Simple time-dependent input parameters for the desired hurricanes to be modeled are supplied by the user and from which calculations of surge heights and windspeeds are made. These parameters, entered at six-hour intervals for a simulated 72-hour hurricane track, are storm position by latitude and longitude, central barometric pressure in millibars and the radius of maximum winds.

Simulated hurricanes varying in intensity, direction of movement, forward speed and landfall location are modeled for a study. For example, in the Tri-State Hurricane Evacuation Study for the central Gulf Coast, a total of 964 simulated storms were modeled for the study area. These simulated hurricanes represented the five categories of hurricane intensity as described by the Saffir-Simpson Hurricane
Scale, five directions of storm movement for landfalling and paralleling hurricanes (N, NW, NE, W, E), two forward speeds of 5 and 15 miles per hour and numerous landfall or nearest approach locations spaced approximately 20 miles apart along the coastline. The characteristics of the simulated hurricanes modeled for a study are predicated upon the meteorological history of the basin; therefore, variation in selected storm parameters between study areas is likely to occur.

The model output for each simulated storm run consists of a surface envelope of water which represents the maximum surge values calculated for each grid point irrespective of the time during the simulation that the maximum height occurred. These values are displayed on printouts on which the grid points are referenced by a system of coordinates. The coordinates, through the use of grid overlays, allow the surge heights to be transferred onto transverse mercator maps of any desired scale. Time-history tabulations for sixty (60) pre-selected grid points are also furnished with each run.

Prior to modeling the desired hurricanes, a maximum of sixty (60) model grid points are selected for which time-histories of surge heights, windspeeds and wind directions are tabulated for at least a 30-hour segment of a simulated storm track. The selected grid points normally represent the locations of critical roads and bridges of low elevation, potentially vulnerable population centers or areas adjacent to significant natural or man-made barriers. The time-history information for each selected grid point lists values at ten-minute intervals for still-water surge heights in feet above National Geodetic Vertical Datum (NGVD), windspeeds in miles per hour and wind directions as azimuths from which the wind is blowing. The time-history information is utilized to determine the pre-landfall hazards times expected in advance of an approaching hurricane. The arrival time of gale-force winds (sustained 40 miles per hour) and/or the time that critical roads or bridges needed for evacuation may be inundated by rising storm surge are commonly the thresholds used to determine the pre-landfall hazards times. The pre-landfall hazards times represent the time period, in advance of expected hurricane landfall, that evacuees will likely be exposed to hazardous wind or storm surge conditions. The time-history data allow emergency management officials to more accurately judge the time at which evacuees may be exposed to storm hazards and permit the timing of evacuations to avoid those hazards.
Due to the large number of simulated storm runs required for a study, the results of the individual simulations are combined into Maximum Envelopes of Water (MEOW), which display the maximum surge value for each grid point in the model for any storm parameter or combination of parameters desired. Variations in category, forward speed, direction of movement and landfall location, individually or collectively, result in differing surge heights calculated for a location. Normally, the MEOWs are prepared by category of storm and combine all other storm parameters to determine the maximum surge heights possible for a location. The MEOWs are utilized in order to simplify the data and because present technology cannot assure precise forecasting of hurricane landfall location to permit confident use of individual storm runs in emergency management planning. The average radii of forecast error for hurricanes with an expected landfall time of 24 hours are 105 miles for the Gulf of Mexico and 125 miles for the Atlantic Ocean. Considering the average radii of forecast error and the clearance times required to evacuate the threatened population of many coastal locations, each jurisdiction under a hurricane threat must prepare for the worst probable effects from approaching storms. The MEOWs allow this data to be generated and presented in an efficient and uncomplicated manner.

The SLOSH model does not provide data concerning the additional heights of waves generated on top of the still-water storm surge. Generally, waves do not add to the areal coverage of the storm surge in a basin and can usually be ignored except for locations immediately along the open coastline or the shorelines of very large bays where significant fetch lengths and water depths are possible. Due to the presence of structures, dunes or vegetation, the waves break and their energy dissipates within a few hundred yards of the coastline.

The data developed from the hazards analysis and other related analyses conducted for a hurricane evacuation study are presented in a technical data report. Local implementation guides are normally prepared for each county within a study area and include the technical data and operational information pertinent to a particular jurisdiction. The technical data allow emergency management agencies to more accurately determine the vulnerable areas and to estimate the time required to safely evacuate the threatened population for a wide range of potential hurricane threats.
PUBLICATIONS OF INTEREST
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SPECIAL PUBLICATIONS

#2. Regulation of Flood Hazard Areas to Reduce Flood Losses, Volume 3. Jon Kusler. 1982. 300 pp. $8.00
#4. Innovation in Local Floodplain Management, Appendix B to Volume 3 (SP #2). Jon Kusler. 1982. 262 pp. $8.00

MONOGRAPHS


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TOPICAL BIBLIOGRAPHIES

#02. Bibliography on Flood Proofing. Anita Cochran. 1977. 9 pp. $1.00

#03. Flash Flood Warnings Bibliography. Kathleen Torres and Anita Cochran. 1977. 22 pp. $1.00