STRENGTHENING LOCAL FLOOD PROTECTION PROGRAMS

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

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Association of State Floodplain Managers

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


Pittsburgh, the host city for the Tenth Annual Conference of the Association of State Floodplain Managers, has a history of flooding extending back to Colonial times. Its citizens' efforts to manage the flood hazard well demonstrate the increased sophistication and effectiveness of floodplain management as it has evolved in the United States in the last two centuries (see the articles by Miklaucic and Edwardo in this volume). The downtown "Point Area"--at the confluence of the Allegheny (left) and Monongahela (right) Rivers--provides several examples of sound floodplain management. The prominent open space park in the redeveloped foreground makes appropriate use of lands subject to occasional flooding. Elevated highway corridors and the floodproofing of prominent landmark structures, together with a comprehensive system of upstream flood control, land use controls, and a coordinated flood warning and preparedness program, all reflect public and private flood damage reduction strategies that, in concert, have significantly reduced the flood hazard in downtown Pittsburgh.

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PREFACE

"Backwaters '86: Strengthening Local Flood Protection Programs" was the theme of the Tenth Annual Conference of the Association of State Floodplain Managers. In spite of our association's name, only 34% of those that attended represented state agencies. The balance were from local governments, federal agencies, private firms, universities, national organizations, and other countries. It is important that we have such a diversity of participants, because improving floodplain management at the local level involves all levels of the public and private sectors.

The papers in this book are taken from the conference presentation. The authors represent all the actors in floodplain management. They include mayors, planners, heads of federal and state agencies, private developers, consultants, and university professors. Only at a national technical conference such as ours can this variety of experience and expertise be brought together.

The Association of State Floodplain Managers hosts a national technical conference annually and sponsors other meetings throughout the year. Through these meetings and our other activities--designing training programs, conducting research, publishing a newsletter, and commenting on national policy issues--we strive to provide our members and others interested in strengthening local flood protection programs with the latest and most useful information. For those who cannot directly participate in our activities, we hope these proceedings will be a useful reference.

French Wetmore, Chair
Association of State Floodplain Managers
ACKNOWLEDGMENTS

The 1986 ASFPM Conference was the tenth anniversary conference of the association. Much time and effort was spent behind the scenes by many dedicated people to make the meeting a truly memorable event.

Our thanks go out to French Wetmore and Larry Larson for their continued support of and faith in the 1986 conference team. We thank Mark Riebau and Mary Fran Myers for organizing the exhibit portion of the conference, and Linda Punch and Andrea Kalinchak for managing registration, records, and other areas.

A special thank you must also be extended to Allan Williams. As the program chair, Allan spent countless hours arranging and coordinating the entire conference agenda. His untiring efforts resulted in a comprehensive, thought-provoking agenda and thus, in a truly successful conference.

In addition, we are grateful to the Tennessee Valley Authority for providing the financial support that permitted the publication of these proceedings, and to the staff of the Natural Hazards Research and Applications Information Center, University of Colorado for preparing this volume.

The ASFPM is a volunteer organization. However, for ten years it has been hosting this major national forum for interested and concerned persons to meet and discuss floodplain management and related issues. Without the interest, involvement, and dedication of all the participants, these conferences would not be possible. The Association of State Floodplain Managers, as well as the entire floodplain management community, owes not only the persons mentioned above, but all the participants, a debt of gratitude.

Dante C. Accurti
Conference Director
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PART ONE
PLENARY ADDRESSES
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FINANCING AND ORGANIZING A FLOOD PROTECTION PROGRAM

R. Timothy Weston
Pennsylvania Department of Environmental Resources

On behalf of the Secretary and staff of the Pennsylvania Department of Environmental Resources, I would like to welcome the participants in the Tenth Annual ASFPM Conference to the Flood Prone State!

Most political leaders, and the Chamber of Commerce, would probably wince a bit at that greeting, but Pennsylvania's vulnerability to floods is undeniable. Indeed, that is why you are here today. Pennsylvania is blessed with abundant water resources, with an average annual precipitation of 30 to 60 inches. Our 10.5 million acres of forest, farms, and urban areas form the watersheds for 45,000 miles of surface streams. Those watersheds, in turn, constitute substantial drainage basins for four major interstate rivers. Pennsylvania's bounty has, at times, also been the scourge of her citizens. Flooding has damaged human settlements from the earliest days of the colonial proprietors. Urban, industrial, and commercial development, as well as clearing of land for agriculture and mining, has increased runoff and simultaneously placed valuable structures and investments in the path of flood waters. Since 1936, just 50 years ago, Pennsylvanians have suffered over 20 major floods, accounting for total damages in excess of six billion dollars. Although there is a tendency to look upon the great floods, such as the disasters of 1936, tropical storm Agnes in 1972, and the Johnstown Flood of 1977, as remote and unprecedented events, the fact is that serious and moderate floods are a part of the regular and natural history of this commonwealth.

In just this past year, Pennsylvanians have confronted three serious flood events—in the northeast part of the state, in the Monongahela River Valley, and just two weeks ago in the Pine Creek watershed just north of Pittsburgh. With an average of one flood disaster per quarter, this commonwealth clearly faces a challenge.

The issue before us—as government leaders, professionals, and citizens—is whether we are prepared to rise to that challenge. Are we prepared to set aside the pat answers and avoid the false hopes of the quick fix, identify the causes of our real problems, and act in a concerted fashion to address those problems? Are we
willing to invest the talent, time, and funds to undertake those programs, projects, and policies that will truly begin to reduce the tide of flood damages?

In posing these questions, my hope is to share with you my personal perspectives—based on experience as a government officer, emergency manager, and professional—on where we have come from, and where I think we are going as a state and society in addressing the flood and storm water damage problem.

For most of the past half century, this state's response to flood problems focused on structural solutions. Recurrent flood damages to existing investments have stimulated recurrent investments in measures to "control floods." If we have not succeeded in taming Mother Nature, it has certainly not been for lack of trying.

The federal investment in Pennsylvania flood control, coupled with state and local flood control projects, has been a multi-billion dollar effort over the past five decades.

In two months, the commonwealth will celebrate the 50th anniversary of the Pennsylvania Flood Control Act—the primary authority under which the Department of Environmental Resources constructs flood reservoirs and local protection projects. Under this program, Pennsylvania has constructed flood control reservoirs worth $216.8 million, and some 92 local levee, channel, and other protection projects. These projects represent a total investment in today's dollars of over $146 million.

The Army Corps of Engineers has invested, in today's dollars, over $2.7 billion on 28 major reservoir projects; with 30 local projects representing another $783 million in efforts to stem flood damages; $69.1 million in federal, state, and local funds have been invested in Soil Conservation Service P.L. 566 watershed dams and projects.

Have these projects worked?
Yes.
Are they a total solution?
Of course not.
Recent disasters demonstrated the benefits of flood projects carried out over the past five decades by state and federal agencies. Pennsylvania State Water Plan data indicate that statewide, natural flood damages would average over $258 million annually, were it not for federal and state flood control structures. Investments in structural control facilities have reduced the commonwealth's residual actuarial risk of flood damage to some $66 million annually.

But flood control projects are neither inexpensive nor foolproof. A dam, levee,
or channel project is only effective within its design limits, and can only control
the types of storm events for which it was conceived. It appears that flood control
efforts have given many communities a false sense of security. Pennsylvania
provides some of the most stark and tragic examples of this "it can't happen here"
syndrome. Following massive investments in flood control along the Conamaugh River
in Johnstown, the city proudly erected a billboard proclaiming the "Flood Free City."
In 1977, the front page of local papers carried a picture of that proud sign,
inundated by the floods produced by a record-breaking summer storm.

Two weeks ago, we witnessed history repeated again. Just one day after the
commonwealth completed a channel improvement project on Pine Creek, a thunderstorm
struck a small tributary watershed. Even though the flood project was not on the
stream carrying the bulk of the flow, it did help—indeed, it lowered local flood
elevations by some four to five feet. But with local precipitation exceeding a 500-
year storm, record-breaking flash floods were unavoidable. What was tragic was the
discovery, after the flood, that more than a few residents along the flood-ravaged
streams had chosen to cancel their flood insurance, believing that the channel
improvement would solve all their problems.

We still have a long way to go, and structural flood control measures alone will
not provide the complete answer. Our approach in this commonwealth has been to frame
a multifaceted program to reduce our risk of flood loss and to improve flood respon-
se. That program integrates structural flood control projects with other efforts—
including floodplain management, water obstructions regulation, storm water planning
and control, and flood warning systems—to frame what, in the terms of our State
Water Plan, is a more "holistic" approach to flood damage reduction. Each element of
that approach involves—indeed requires—active participation by both state and local
government. Each element requires not just token support, but long-term commitments
of time, talent, and fiscal resources to make the program work.

Federal and State Flood Control Projects

First, we recognize that some significant further investments in structures are
warranted to protect existing flood-prone communities.

Based on Corps of Engineers assessments, the commonwealth has supported im-
plementation of a series of 13 priority federal water projects, to be developed over
the next decade. Ranging in size from the $229 million Wyoming
Valley project, to the $650,000 ice jam control effort at Oil City, these measures
will entail expenditures from federal, state and local funds totaling over $473 million. Another 44 projects have been funded by the Pennsylvania General Assembly, and are in various stages of design and development, reflecting an additional investment in state projects of $78.7 million.

But investments in flood control projects during this time of fiscal limitation and budget restraint requires more than simply a recognized need and an engineering concept. The policies governing federal and state participation in flood control are changing. The state and federal governments recognize a continuing responsibility to participate in development of such water projects, but at the same time, local governments and citizens who receive the benefits of these efforts are being asked to become fuller partners in making those investments and investment decisions.

Under current federal policy, as reflected in the pending omnibus water resources legislation, nonfederal sponsors are required to commit to significantly increased sharing of the costs for construction, operation, and maintenance. Local sponsors must not only acquire all necessary lands and arrange for required utility relocations--as has been true under past practice--but now, and in the future, nonfederal sponsors must at a minimum contribute 25% of the total project costs--5% in cash up front. For the federal projects slated in Pennsylvania, this means a nonfederal share nearing $120 million.

The commonwealth has indicated its commitment to bear a portion of this partnership. In February, Governor Thornburgh announced a five-year capital budget plan to underwrite one-half of the nonfederal share of all federal projects in Pennsylvania. In essence, we are asking our local governments--the localities served by these projects--to pay 12.5% of the total project costs.

But at a time when local government budgets, too, are hard pressed by statutory spending limits, debt ceilings, and tax millage caps, how do we expect these local obligations to be fulfilled? Are our local governments organized to undertake such financing responsibilities--particularly where one project benefits a number of communities? Are we prepared fiscally and institutionally to move ahead in the flood control field?

Unfortunately, the answers to these questions are not simple. Yes, some of our communities most likely have the resources to carry out their project obligations. But others, such as Lock Haven and the Wyoming Valley, face difficult institutional and fiscal challenges, and to address these, we may need to try some new (or borrow some old) governmental arrangements. One concept we are earnestly studying involves
the creation of "conservancy districts." Modeled on similar arrangements in the state of Ohio, a conservancy district would be a special regional entity, established under state law, covering the territory of a multimunicipal project (such as Wyoming Valley) or an entire watershed. The district would have the full authority to finance, develop, operate and maintain flood control, storm water, and other water-related facilities and projects. But for such an entity to be effective, it must have a reliable source of revenue—and as we all know, flood control is not a very vendible product or service. Conservancy districts must be given the authority to adopt and collect independent assessments on benefited properties, ad valorem taxes, or other dedicated taxes to recover the cost shares required under federal and state laws. It is on this issue, regarding whether taxing powers should be given to a special unit of government, that we may expect the greatest debate.

Floodplain and Storm Water Management

I would not like to give the impression that projects are the beginning and end of the commonwealth's program. Far from it.

Common sense regulation of new development in our floodplains, floodways, and waterways is essential in order to assure proper siting and design of new damage-prone structures, and to avoid obstructions which may further exacerbate flood flows and elevations.

This state has enacted and is enforcing mandatory requirements that all flood-prone communities implement floodplain management standards. In this instance, the main responsibility for action lies at the local level, which has traditionally claimed and exercised control over zoning and building development. Experience has taught the lesson, however, that the lack of action at the local level may—in future floods—shift the burden of damages far beyond municipal borders. For this reason, the General Assembly provided two strong finance incentives for floodplain management programs. Grants from the Department of Community Affairs help communities to defray the cost of developing and implementing floodplain ordinances. Conversely, any community identified as flood-prone which refuses to carry out floodplain management in accordance with state and federal standards is, by law, cut off from all state funding.

Complementing the floodplain management programs, the commonwealth enacted one of the most sophisticated, and we believe effective, programs to regulate dams, water obstructions, and other encroachments which may impair flood flows or contribute to
flood safety problems. That regulatory law lays upon owners of dams and operators of flood control structures, specific construction, operation, and maintenance responsibilities. Recognizing that Pennsylvania has the nation's largest inventory of high hazard dams--many of which are relatively old and designed to less than current standards--the people of this state have authorized a $300 million program of low-interest loans for the repair and restoration of dams, flood control structures, and other critical water facilities.

Finally, we are beginning to carry out the promises of the Pennsylvania Storm Water Management Act. Adopted in 1978, this act mandates the development by counties of watershed storm water plans to assess, on the basis of hydrologic units, storm water runoff, floodplains, and related problems. While the focus of the watershed plans is the development of uniform criteria to avoid and control accelerated runoff from future development in the watershed, these plans also provide a rational evaluation of existing problems and priority needs. Once adopted by each county, these plans become binding on the municipalities in the watershed, who must in turn regulate development to the plan's standards. In 1985, the General Assembly made its initial modest appropriation of $250,000 for 75% matching grants to support county preparation of plans, a figure which will be doubled in this coming fiscal year.

Here, again, county and local governments have major responsibilities for program direction and implementation. As seen in the recommendations of several pilot storm water plans developed in Allegheny County, new institutional arrangements and relationships may be necessary to fully realize these efforts. As in the case of multimunicipal flood control measures, storm water management in a watershed may require concerted actions which cross political boundaries. The runoff in one community may best be handled by a series of storm water retention ponds in another. Again, the concepts of "conservancy districts" or "storm water authorities" have been suggested as alternatives for joint municipal action and merit serious consideration.

**Flood Warning Systems**

Most of the programs cited to this point deal with what to do before a flood. But what happens when a storm strikes? One of the most essential and often forgotten elements of a state and local flood protection program is warning. Floods may be unavoidable; surprise is not. We have the techniques to provide better warning and preparation, if we have the commitment to carry them through.

Last year, the Susquehanna River Basin Commission coordinated the development of
proposals for significant improvements in flood warning throughout the area of the Mid-Atlantic River Forecast Center—a territory stretching from northern New Jersey to the James River in Virginia. An interagency task force—comprising state agencies, the National Weather Service, USGS, and Corps of Engineers—identified gaps in the existing system and proposed recommendations for specific improvements to data acquisition, transmission, analysis, and dissemination of flood predictions. The modest investments called for in the proposal—a mere $5 million—had a benefit/cost ratio well in excess of eight to one. Backed with the commitments for cooperation among all the agencies, Congress—even in a time of fiscal restraint—funded this demonstration program for improved warning.

To complement this effort, the commonwealth has undertaken accelerated efforts to improve our local flood warning networks. This year alone, the Department of Environmental Resources has committed some $500,000 toward installing the most modern, integrated, satellite-linked gauging stations across the state, particularly in vulnerable flood-prone watersheds. Complementary efforts undertaken by the Pennsylvania Emergency Management Agency and National Weather Service are aimed at spreading the IFLOWS systems into the hands of county and regional flood warning network operators.

The problem is that the commitment to such warning systems, particularly at the local level, wanes in direct proportion to the length of time since the last flood. Local leaders move on to other issues, and slowly the trained—often voluntary—personnel necessary to keep such a system functioning are dissipated or lost. This is not a technological problem but an institutional issue. In those areas where such systems have remained active and successful, one common element is clear—assignment of the responsibility for running the system to an ongoing county or municipal agency, such as the county emergency management center, a conservancy district, or similar organization with permanent, full-time staffing.

I have tried to describe a few of the many streams that must flow together to make up a workable flood protection program at the state and local level. We all must broaden our perspectives—no one program, agency, or project will solve the challenge of flood damages. Too often, it is easy for us—as government officials—to become enamored with the virtues of our own particular efforts. Flood waters do not flow from program to program; they are a whole. So, too, our efforts to prevent and reduce the ravages of floods—at the federal, state and local levels—must be a whole. This is the challenge for this conference, and for our work in the years ahead.
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AN ASSESSMENT OF THE ENVIRONMENTAL MOVEMENT IN "MIDDLE AGE" AND THE RELATIONSHIP OF RIVER PROTECTION TO FLOODPLAIN MANAGEMENT

Douglas P. Wheeler
Sierra Club

As we confront the environmental agenda for the future, what can we expect of a movement that in some ways is as old as this country (the Sierra Club will be 100 years old in 1992), but in other ways really only began in the late 1960s? Although the name of the movement has change from conservation to environmentalism, and although the emphasis is now correspondingly different, the values and resulting actions remain much the same.

In fact, the movement has made substantial progress since the 1970s—success reflected by the institutionalization of concern for environmental quality. The formation of the Council on Environmental Quality, the passage of the National Environmental Policy Act, and the creation of a statutory basis for clean air and water are all major accomplishments reflecting the nation's growing awareness of and willingness to act to reduce environmental problems. This institutionalization was sufficiently strong to withstand direct challenges by the Reagan administration. Despite the efforts of such Reagan appointees as Anne Gorsuch Burford and Bob Burford, the "de-institutionalization" and dismantling of federal agencies charged with protecting our environment has failed.

Why?

Principally because of continued strong public support for the values advocated by the environmental movement and because of corresponding political awareness and influence. In the fall of 1985, for example, in Virginia and New Jersey, gubernatorial candidates of both parties supported environmental agendas. In 1986, similar strong support could be found in other election races from California to Florida.

To be sure, the definition of environmentalism has broadened. We are all becoming environmentalists in our growing recognition that the quality of the natural environment and human health are interconnected. This realization is reflected by recent surveys. A recent Harris poll found that
93% of those polled agreed that "pollution of lakes and rivers in toxic substances from factories is a serious problem,"

67% favored passage of a $10 billion Superfund extension (five years),

79% felt that pollution from acid rain is a "serious problem."

The results led the polling agency to conclude that "one of the real sleeper issues may well be that of environmental controls."

But the most important recent development that augurs well for the future effectiveness of the environmental movement may be the growth and virility of not-for-profit organizations at the state and local levels as the federal government eschews its responsibilities. The Sierra Club is a good example. The club experienced great growth in the early 1980s, thanks in large part to the alarm and dismay generated by the actions of Secretary of the Interior James Watt. Currently, membership is at its all-time high since 1892--375,000--with at least one chapter in every state and more than 300 local groups. The hope and goal of the Sierra Club is to have 500,000 members by its centennial in 1992.

The many volunteers of the club are supported by staff at the chapter level, in regional offices, in Washington, and at headquarters in San Francisco. This results in a potent partnership of volunteers and professional staff--a partnership whose transition from the sometimes emotional response to environmental degradation that characterized the movement in the 1970s to the problem solving of the 1980s accounts for the often heard observation that the environmental movement has lost its fervor. Perhaps that is true. But the movement has not lost its strength or commitment as the results of our work and the polls show.

However, with the recent changes in the public and private roles concerning the environment, one can ask what the Sierra Club (indeed, what the environmental movement) is today. A look at recent legislation--the farm bill and Superfund bill--provides some insights.

First, the Sierra Club is now finding and calling on new allies. With the broadened national interest in environmental matters, many groups--the farming community and floodplain managers, are two examples--are finding that their interests are consistent in many respects with those of the Sierra Club. Furthermore, the club is taking a more constructive approach to problems and looking for new solutions. It
is no longer always sufficient to simply oppose actions that might be detrimental to the environment. An effective organization must also offer constructive solutions, alternative policies. The Sierra Club is doing that. Moreover, it is more and more relying on the mobilization of local citizen concern to protect the environment; indeed, the club develops its agenda by asking its members to identify issues.

National legislative priorities are determined by canvassing local groups and chapters, and policies can now be proposed by any member before being reviewed by the appropriate issue committee and approved by the Board of Directors (in the case of national concerns). In local cases, chapter policy prevails so long as it is not inconsistent with national policy. Thus, at times the club may appear to speak with many voices—and it does—but there is (or is supposed to be) coordination and consistency among those many views.

This process has resulted in a statement of national club policy on issues of concern to floodplain managers:

FLOODPLAINS

Despite large expenditures to reduce flood damage, the total annual loss continues to grow. Dams and levees are frequently not effective flood control measures, but merely divert flooding to new locations.

In flood protection, emphasis should be placed not on structural controls, but on floodplain management, including flood proofing and relocation of existing structures as appropriate and zoning for compatible uses to control future development. To maximize environmental benefits, floodplains should be utilized for wetlands, agriculture, parks, greenbelts, groundwater recharge, buffer zones for protection of instream uses, and other uses compatible with the flood hazard. Structural devices should not be used where they would encourage development in floodplains. Coastal floodplains must also be protected.

Consistent with this policy and its role as an agent of constructive change, the club is actively involved in solving problems of watersheds from Florida to California. In Florida, Governor Graham's "Save Our Everglades" Coalition of state government, federal agencies, and private organizations (including the Sierra Club) is now working to protect the Everglades ecosystem threatened by growth and human-kind's manipulation. The Sierra Club Florida Chapter has been given specific responsibility for restoration of the Kissimmee Watershed—an area whose natural values have been destroyed by channelization. That massive construction project not only destroyed riparian habitat, but also failed to meet its original flood control objective. The State of Florida has now funded the construction of a diversion weir,
and restoration has begun on an experimental basis. The club will monitor the ex-
periment and seek support for a complete project if the experiment proves its feasi-
ility. The project involves an ironic role reversal by the Army Corps of Engineers,
as together we work to obliterate the impacts of earlier manipulation.

In California, environmentalists are watching another experiment—the substitu-
tion of palisading for riprap along a 2000-foot eroding section of the Sacramento
River in Woodson Bridge State Park, north of Clovis. The $400,000 expenditure for
this project (at $150 per linear foot after administration costs) is modest compared
with the original Corps commitment to $3.5 million this year and $20 million in years
ahead for riprap (at $250 per linear foot). The Sierra Club supports innovation and
the exploration of alternatives and congratulates the Corps on its willingness to
abandon failed approaches. Even more satisfactory is the fact that, on the
Sacramento, in the long run the project may result in a meander belt, within which
the river would be allowed to follow its natural course.

Such innovation to achieve flood control objectives minimizes risk to human life
and property while remaining sensitive to the need for environmental quality and open
space. This creative approach is one of the major objectives of the President's
Commission on Americans Outdoors, chaired by Lamar Alexander, Governor of Tennessee.
I am a Senior Advisor to the Commission and invite your participation in the develop-
ment and implementation of a bold plan to create a national network of protected
floodplains through the use of cost-effective incentives. I convey the express
invitation of the Commission that the Association of State Floodplain Managers organ-
ize a task force to provide information and ideas to develop such a plan. This is a
truly unique opportunity which I urge you to seize, so that working in partnership we
might move toward mature, constructive commitment to the maintenance of environmental
quality.
FIFTY YEARS OF EVOLVING FLOODPLAIN MANAGEMENT

H.J. Hatch
U.S. Army Corps of Engineers

I have had personal involvement with two events which make the ASFPM annual meeting particularly meaningful to me. The first occurred in 1972 in Harrisburg, Pennsylvania where all of my household goods were stored in the floodplain. Those goods were lost during the flood caused by Hurricane Agnes. The second occurred in 1975 while I was commander of the Nashville District. At that time, we experienced a "regulated" flood of record at Celina, Tennessee. Many of the houses under water had been built in a 100-year floodplain that had been undeveloped and clear when we published a floodplain information report several years earlier.

The first event gave me empathy for flood victims; the second convinced me that we must do a better job.

The following is a review of the important changes in floodplain management that have occurred since passage of the Flood Control Act of 1936--particularly concerning the federal role in reducing flood damages--as well as an update of the Corps' Civil Works Program.

Sunday, June 22nd, 1986 was the fiftieth anniversary of the Flood Control Act of 1936. This legislation marked the beginning of federal flood control on a national scale. Since 1936, approximately 900 flood control projects authorized by Congress have been built--including approximately 400 flood control dams. The Corps has also built thousands of miles of levees, flood walls, floodways, and improved channels. While we have worked for 50 years to control floods, during the last 25 years we have also sought to promote and strongly support floodplain management by state and local governments. One of the most significant changes over the past five to ten years has been the increase in state and local involvement in floodplain management. We applaud this change, and we especially applaud the efforts of the Association of State Floodplain Managers. You have been the key to making this increased involvement happen. The Corps supports your organization and its goals, and we share many of the same objectives. As I will discuss later, these relationships will be even more important in the future.

The 1936 act clearly defined flood control as a federal (national) interest. However, because it addressed only "flood control," a more comprehensive approach was needed as indicated by subsequent Flood Control Acts of 1938, 1941, and 1944. The 1938 act allowed "evacuation" of flood areas when such action would reduce protection costs of authorized flood walls or levees; the 1941 act authorized emergency money
for flood emergency preparation--"flood fighting"--and repair and restoration of flood control works; and the 1944 act provided a basis for consideration of major drainage improvements in flood control investigations and reports, recognized "rights and interests of states" in water resource development, and required federal coordination and consultation with states.

In 1960 the Corps began to pursue a more comprehensive flood damage reduction program authorized by the Flood Control Act of 1960. The act initiated the National Flood Plain Management Services (FPMS) Program designed specifically to support state and local involvement in floodplain management. Upon request, the Corps provides technical services and planning guidance to support comprehensive floodplain management planning by state and local governments, as well as assistance to state and local governments in the preparation of floodplain regulations. This work includes interpreting the flood data in our reports, providing additional data where needed, and giving advice on how to lay out and evaluate floodway areas; we provide flood hazard information on specific sites and short reaches of streams; and we provide technical assistance and guidance to federal agencies, states, and local governments on floodproofing structures and other nonstructural measures. Also, in cooperation with the Federal Emergency Management Agency, we strongly support the National Flood Insurance Program. The FPMS Program has promoted preventive as well as traditional measures to reduce the flood hazard. Nonstructural solutions, i.e., floodproofing and evacuation, have evolved as alternatives to the classical structural solutions. Even beyond those measures, a greater reliance and dependence on zoning by local interests has resulted in prudent current and future development.

Since 1960, the Corps has evolved from prime mover through advocacy of flood control projects to its present posture of neutral plan and policy formulation and evaluation. Both through our regular construction-oriented programs and our regulatory programs, the Corps has become somewhat of a referee, balancing the objectives of diverse special interest groups (i.e., development vs. conservation) by using a "fish bowl" planning approach to problem identification and solution determination. We did not initiate these changes on our own. Environmental concerns, cultural changes, and Administrative directives have led the way.

In 1966 a Presidential Task Force proposed the Unified National Program for Managing Flood Losses. The plan was published in House Document 465. Among other things, it recommended 1) evaluation of alternative flood control plans including nonstructural measures, and 2) consideration of flood control benefits to future as
well as existing developments. (These concepts were included in the Principles and Standards of 1973 and are a part of the current Principles and Guidelines for studying a proposed water resources project). President Johnson in his letter transmitting the task force document, stated that the key to solving the problem lies, above all else, in intelligent planning for state and local regulation of the use of lands exposed to flood hazards.

Since then, significant new federal legislation and activities have affected the role of state and local governments in floodplain management. Since 1966, the philosophy of floodplain management has matured. Floodplain managers now explicitly recognize that conditions at one location are generally dependent upon events elsewhere on a river or coastal system and, beyond that, upon events in the total physical system of which a floodplain is a part; multiple purpose management has replaced single purpose management, even though flood losses and threats to life and health remain priority concerns; evaluation of alternative flood loss reduction strategies following from House Document 465 has replaced a predisposition to rely upon physical structures for flood protection; the responsibility to preserve and restore natural and beneficial floodplain values has been recognized; and the need to ensure public involvement in floodplain use decisions has been recognized.

There have been other significant developments since 1966: the preparation of flood hazard maps was accelerated; federal flood insurance was made available in return for community exercise of floodplain regulation; federal planning, technical assistance, and construction grants were made available to states along with area-wide waste treatment facility planning; financial assistance was made available for defining and enforcing permissible land and water uses in the coastal zone; a federal permit system was developed to more clearly monitor dredge and fill activity, which often affects floodplains; federal cost sharing was extended in principle to "non-structural" measures directed primarily at flood loss reduction; federal water resources planning principles and procedures moved toward a more consistent evaluation of federally funded management measures; and required environmental impact assessments and statements forced consideration of alternative plans affecting floodplain use and development.

Since President Carter's 1977 executive order on floodplain management, the Corps, as well as all other federal water resource agencies, has become a leader by setting examples for other levels of government and public and private organizations. By inference, state and local governments are similarly urged to exercise their own
floodplain management prerogatives with new incentives, regulatory tools, and a comprehensive management philosophy.

Beginning with the 1936 act, a myriad of laws and regulations have been enacted that impact on Corps planning. Many of these have required the government to consider a wide range of effects that might result from the implementation of various plans. To fulfill this mandate, the Corps now employs a wide array of physical and social scientists including economists, biologists, archeologists, environmentalists, and engineers.

One of the Corps' requirements is to perform benefit-cost analyses. Through the early 1940s, the only justification needed for a project was a District Engineer's statement that benefits exceeded costs. In 1946 the Federal Inter-Agency Committee on Water Resources began formulating principles and procedures for determining benefits and costs of water resource projects. In 1950, the committee published a report (commonly referred to as the "Green Book") which serves as one of the essential bases for benefit/cost analysis.

The Corps must also follow the NED objective, i.e., planning for flood damage reduction must reasonably maximize National Economic Development (NED) consistent with protecting the nation's environment. The statement of the federal objective, however, has gone through an evolving and sometimes confusing process. In 1969, the NEPA (National Environmental Policy Act) added the environmental quality (EQ) objective. The Flood Control Act of 1970 provided additional objectives of regional economic development and social well-being. The current emphasis on reasonably maximizing NED benefits tends to improve benefit-cost ratios and returns on both federal and nonfederal investment.

Today's opportunities for additional major water resource projects appear to be limited for a number of reasons. One is that the best projects have already been identified and built. The remaining candidates become economically marginal when subjected to today's environmental mitigation costs, cost sharing formulas, relative costs of construction, and high interest rates. Budgetary limitations, the absence of major authorizing legislation since 1976, and the deficit crunch have tended to reduce emphasis on developing fish, wildlife, and recreation areas and to limit development of water supply storage for future uses. Thus, projects serving multiple functions have been limited. In effect, most projects being considered today are local in scope and limited in purpose. Passage of new water resource legislation would improve this situation by clarifying cost sharing and local cooperation
requirements and by encouraging a more active role for state and local governments in water resources development choices.

Thus, in contrast, this is an exciting, upbeat time for civil works. Construction projects are being funded. There are 41 projects in the FY 85 supplemental bill and 19 others have been included in the FY 87 budget with OMB's blessing. The FY 87 budget request is for $3.1 billion, a 10% increase over FY 86 in an otherwise very austere federal budget with a $199 billion deficit. Most of the increase is in "Construction, General"--indicating a higher priority for water resources after a long, dry spell.

We are undertaking new projects, but the way we are going about them is changing radically. I can give you the reason in two words: cost sharing. Cost sharing is affecting everything we do. The Chief of the Corps and I often emphasize our role as "Leaders in Customer Care," but local sponsors are now, in the truest sense of the word, more than our customers; they are our partner. Local sponsors are customers for technical services and partners in federally supported solutions. They share the cost of planning as well as construction.

In project planning, as you know, we operate on a two-phase system--the "recon" and "feasibility" study phases. Under cost sharing, we continue to do recons as we always have; we determine a federal interest and determine if the projects may be feasible, etc., at 100% federal financing. However, locals are now required put up 50% of the cost of the feasibility study. Thus, locals have a chance early on to show they are serious about a project. By putting up funds, locals have a say in how the study will be carried out. (The Golden Rule is "He who has the gold, makes the rules.") Thus project proposals will reflect local concerns--concerns that locals are willing to partly fund. Of course, the process could result in scaled-down proposals; sponsors would have to say what they can afford as well as what they want. They might tell us, "Plan for a 2% flood protection project, we can't afford the standard flood plan." Obviously, this places a burden on us to fully explain the consequences of implementing low-level protection, i.e., reduced warning time and increased hazards. The federal government has not given up deciding how we plan and design. The local sponsor, the Administration, and the Congress set forth what projects we will build, and we have the responsibility to build "a safe, environmentally sound, quality project or no project at all.

In project construction, the local cooperation agreement (LCA) is the contract between the federal government and the local sponsor. It includes an estimated total
project cost, a division of federal and nonfederal obligations, and specifications of what and when to build. It is a much more businesslike system than has been used in the past. The Corps must be an engineering and construction manager and a contractor as well. We have been negotiating LCAs with sponsors of 40 projects in the FY 85 Supplemental Appropriations Act (P.L. 99-88). As of June 1986, nine LCAs had been executed by the Assistant Secretary of the Army for Civil Works and local sponsors. They are Virginia Beach Streams, Virginia; Norfolk Harbor, Virginia; Barnegat Inlet, New Jersey; Richmond Local Protection, Virginia; Kill Van Kull, New York and New Jersey; Little Dell Lake, Utah; Jonesport, Maine; Mobile Harbor, Alabama; Baltimore Harbor, Maryland and Virginia. Eleven more LCAs are under review by the Assistant Secretary, and OMB and approval is imminent. We still have five LCAs to be transmitted to the Assistant Secretary for review. We expect to have agreements in hand for most of them by the June 30, 1986 deadline. We are under the gun; we must have all LCAs signed by June 30, or the funds will no longer be available from PL 99-88. Our guidance is to stick close to the provisions of Senate Bill S 1567, now referred to as the Senate version of HR 6.

For the past sixteen years we have been asking, "Will this be the year we get a bill with new construction starts?" This year looks better than ever. The House passed its version, HR 6, last November by an overwhelming vote. It authorizes 309 projects, at a total cost of up to $21 billion. The Administration has expressed strong reservations over the bill. The cost sharing provisions contained in the bill are not considered adequate, and there are numerous other problems. The Senate passed its substitute (S 1567) in March by voice vote. It authorizes 189 projects at a total cost of about $13 billion and represents a compromise on cost sharing worked out last summer between the Administration and Senate Republican leadership. We are hopeful about the conference committee effort to reconcile the two bills. However, it is clear the result must be similar to S 1567. Senate members of the conference committee have a very good selling point for their version: the Assistant Secretary of the Army for Civil Works' assurance, given in several public forums, that "the President would sign this bill (S 1567) today" and OMB's assurance that he will veto the House version. Passage of a bill will let locals and the Corps get on with orderly planning and programming. All sides will know the ground rules, and with a greater local share, the Administration and Congress will be able to spread federal funds over more projects.

On the other hand, tax reform--HR 3838--will tell "the other side of the story"
and its consequences are still unknown.

Regardless of the outcome of the omnibus bill, I want to re-emphasize my personal support for a strong and active Flood Plain Management Services Program. We are seeking increased funding for that program even during these times of budget austerity. The program is a keystone in the federal, state, and local partnership to reduce flood losses, and I look forward to our continued close cooperation with your association.

I also wish to emphasize the great importance that I place on our active participation with other agencies on the Interagency Flood Plain Management Task Force chaired by FEMA. Within the Corps, we strongly support the task force and feel that it will play an increasingly stronger role in helping to guide federal programs that have significant influence on how the floodplains of our nation are used and managed.

Despite the achievements in flood control over the past 50 years, annual flood damages currently exceed $3 billion and are still rising, largely because of mushrooming residential and industrial development on vulnerable floodplains. The solution is true "floodplain management" by local, state, and federal governments working in partnership. The tools needed will include structural as well as non-structural solutions, and the program's effectiveness will come about only through state and local leadership and involvement.

Clearly, the federal role--the Corps' role--is changing. As the pressures of federal deficits drive federal budgets down (or restore growth) and Administrations further the philosophy that identifiable beneficiaries should bear more of the cost of projects, federal programs will better reflect the federal/local partnership I have discussed.

I still cannot solve that Celina, Tennessee problem.

You can. . . Let's work together to do it!
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PART TWO
LOCAL PROBLEMS, TRANSFERABLE SOLUTIONS
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RUDD CREEK MUDSLIDE OF 1983

Max Forbush
City of Farmington, Utah

The threat of flooding in May of 1983 did not appear to be that serious to Farmington residents and its public officials. True, during the 1930s, the city had a seige of flooding and debris flows caused by torrential rains in the mountains adjacent to Farmington. During earlier years, overgrazing was the cause of flooding. Following these early floods, the CCC constructed dikes along four of the five stream channels in Farmington. The fifth stream channel normally carried nothing more than a trickle coming from spring areas of Rudd Canyon. Mitigation efforts were not thought to be necessary.

The winter of 1982 and spring of 1983 yielded excessive snowfall and moisture causing heavy soil saturation. Cold weather and precipitation continued abnormally until mid-May 1983. The weather then changed drastically to the other extreme. Two weeks of 90-95 degree temperatures accelerated snow melt and suddenly all of Farmington's five stream channels became unmanageable. The city mobilized forces and called on volunteers to perform sandbagging operations. Within a short time, several hundred volunteers responded. During the next three days, the city, with its volunteer crews, had the flood waters controlled.

On May 30th, Memorial Day, the community was quiet, a sense of calmness prevailed. At 7:00 p.m. residents living at the mouth of Rudd Canyon were shocked at a terrible rumbling sound coming from Rudd Creek. What they heard was the beginning of a mudslide which dumped approximately 100,000 cubic yards of rock, mud, tree limbs, and other debris into a four-block area. Five homes were destroyed outright. Four others were damaged beyond repair. In addition, approximately 25 to 30 other homes sustained heavy damage. Luckily the mudflow occurred at a time when people were awake and alert, and there were no human fatalities. The slide originated two miles east about 2,500 to 3,000 feet above the residential neighborhood. Approximately 15,000 cubic yards of material broke off from the heavily saturated slopes high in Rudd Canyon and descended the canyon, gaining momentum because of the steepness of the grade and pulling off additional material on its way. The canyon was literally scouried to bedrock by the tremendous energy produced by the slide. Boulders as large as automobiles ripped away vegetation all the way down the canyon. By the time the slide reached the bottom, the rock, trees, dirt, and water had mixed to a consistency of wet concrete. The force of the slide blew out a natural barrier that had protected homes from Rudd Creek's normally small stream, and the backyards of several
homes became immediately exposed. In one of the homes a family of seven was eating their evening meal. Upon hearing the noise, the father looked out the window and saw a wall of mud headed towards them. They quickly evacuated by car and watched as their home was moved off its foundation and deposited 200 feet away. This house was on the outside edges of the mass that hit the rest of the area. The debris flow continued for five days. A ten block area was originally evacuated. Gradually, as the hazard area became more defined, most residents were allowed to return.

Farmington was taught a valuable lesson in emergency preparedness and response. Until 1983, mudflows in Utah were not all that common; as most people would think, Utah is a fairly arid state, receiving about 15 inches of rainfall annually.

Farmington officials and citizens were shocked to see the amount of damage. Farmington is a city of 7,000. It had at the time, 15 full-time municipal employees and a volunteer fire department. Elected and appointed officials knew they had to move rapidly and quickly with their scarce resources to allay fears and get the community back on its feet. The city was pleased with the sensitivity of FEMA personnel as they conducted damage assessments, and was also impressed with the cooperation among all levels of government and volunteer organizations.

FEMA and state officials met with city officials to determine an acceptable approach for mitigating damages from future mudflows. Only a small portion of a larger detached fractured area had sloughed off high in the canyon. The larger detached area still remains perched above the city. Federal, state, and local officials knew a mitigation plan was essential. FEMA agreed to assemble a team of experts to review the hazard potential of all of the canyons along Utah's Wasatch range. Their mission was to identify hazards and recommend mitigation measures. The mitigation recommendation for Rudd Creek was construction of a debris basin. A decision was made to build the debris basin at the mouth of the canyon encompassing the area of most devastation. A ten lot subdivision was affected. Six houses on the lots were either destroyed or damaged beyond repair; two houses were severely damaged but worth salvaging; one house sustained no damage; and the remaining lot was vacant. The basin was designed to catch future mud flows allowing excess water to escape through a specially designed storm drainage system.

While mitigation decisions were being made, Farmington received excellent cooperation from Davis County and the Utah State National Guard in removing mud in the public streets in the affected area. The mud covered entire blocks, and in some areas had been deposited to a depth of 12 feet. Initially, FEMA indicated that they
would not cover the expense of removing the mud on private property. Meanwhile, local ecclesiastical units of the Mormon church (called "wards"—each comprised of approximately 500 people) were assigned two or three affected families. The wards were to restore and make whole the damaged property of those families willing to accept the help. As cash contributions were received to rebuild homes and landscaping, mud and debris were removed quickly from the less devastated areas. Approximately 30 properties were assisted in this manner by neighbors and fellow community members. Two blocks were so heavily devastated that it was impossible for volunteers to remove the debris. FEMA made the decision to remove debris from private property since heavy mud and debris flow had deposited dead animals and other material in the heavily devastated two block area. The deposits constituted a threat to public health.

Mitigation efforts to prevent future damages began once the final report and study of the FEMA team of experts was delivered to the city. First, the city proceeded on a plan to acquire property for the debris basin. This effort required a great deal of cooperation and coordination among state, county, and city officials. The estimated cost of the debris basin project was set at $1 million, and the final cost coincided with the estimate. Two hundred thousand dollars was provided by the federal government through the HUD "Small Cities Community Development Block Grant" program. Farmington had previously received approval for that amount to build a fire station, and the city agreed to redraft the scope of work in the grant so that the funds could be used for the debris basin. In exchange, the state was able to assist the city in getting another federal grant for $200,000 through the HUD Jobs Bill program. An additional $600,000 was granted to the city by the newly created Utah State Disaster Relief Board.

Property acquisition for the project became an enormous undertaking. Lively discussions were held with property owners about property values. The big question city officials faced was, "How should the property be appraised— at existing or predisaster market value?"

Eventually, the appraisal was made based on the assumption of a mud-free residential lot plus the value of the house, if still standing. Using this formula, the city was able to treat property owners fairly. In addition to property compensation, homeowners received relocation assistance as required by HUD.

The next task of the city was to construct the debris basin during the winter. City officials and area residents were terrified at the thought of being left
unprotected for the next runoff season. The construction contract was awarded in December, and the basic structure was completed in April of 1984.

There are still pending dangers due to Rudd Creek. Since 1983, every spring brings anxiety as the local population wonders if the detached land mass above the city will give way. The city has completely restored public services in the affected area, and the debris basin is now nicely landscaped. In addition, protective berming has been installed below the debris basin as a second line of defense against future mudflows. The city has also installed, by contracting with the University of Utah, an electronic monitoring system in Rudd Canyon. Installed prior to the spring runoff in 1984, the system proved effective. Signals on earth movement from the slide area were sent electronically to the Davis County Sheriff's office located in Farmington, city officials were quickly advised of the earth movements, and area residents were notified and precautions taken. The city was able to avoid any damage during 1984. The monitoring system is now activated each spring, and area residents are comforted with the knowledge that the monitoring system is in place.

The 1983 mudflow experience taught Farmington city officials and residents valuable lessons. 1) Volunteer citizens are an important asset in emergency preparedness and response. 2) Cooperation and communication among city, county, state, and federal governments is essential in developing and working out solutions to serious problems. 3) Natural hazards can be mitigated by careful land use planning and zoning.
Many of the main thoroughfares in Memphis are located adjacent to major drainage systems. As pressures for development along these roadways have increased, attention has been focused on the land use of property determined to be in floodplains. The public, consequently, has begun to request revisions in floodplain delineation requiring improved hydraulic models of these floodplain areas. The public has realized that these improved models can be used to modify the floodways and recover valuable property. In reaction to these requests, local governments have recognized the need for an extensive water resources management plan of which floodplain management through computer simulation is an integral part.

In the fall of 1982 the city of Memphis began notifying the public of proposed FEMA flood boundaries and received little public reaction with the exception of a few requests for modifications from property owners who felt the boundaries were in error. Most of these initial revision requests were approved and the program was adopted.

Following a period of inactivity, primarily due to slow development in the area, the public works department of the city received several requests for modification of the original Flood Insurance Study (FIS) and found themselves in the position of reviewing revision requests without in-house expertise. As the revision requests became more frequent, they also became more complicated, and the public works staff felt they could no longer approve revisions without a more thorough review process.

At this point the Civil Engineering Department at Memphis State University became involved in the effort to establish a process under which modifications to the major drainage tributaries would be accomplished only after careful review of the proposed changes as they related to the FIS, channel maintenance, and future development. Initially, the university offered to help the city develop a comprehensive surface water management philosophy to help predict and control the impacts of natural as well as human-made changes in major drainage tributaries in the Memphis area.

The university and city arrived at an agreement, the primary objective of which
was the establishment of a data repository containing historical information on the three major drainage basins in the Memphis area as well as current updates on physical changes occurring in those basins. In conjunction with the physical data that was to be assembled, the FIS models and their boundaries were also to be maintained as well as records of all future modifications. While this information had been compiled previously, it was available only in printed form from several different sources. The university proposed to act as the central source for this information in order to better focus community efforts concerning the management of surface water drainage. The university was selected because it had both faculty with technical expertise in hydraulics and hydrology and computer facilities that could be accessed by the public. The university's computer was capable of storing the massive data base and could execute Army Corps of Engineers Hydraulic Engineering Center (HEC) models in a minimum amount of time. It was clear that by establishing a central repository, program modifications and changes in the data base could be easily maintained. Also, technical advice could be provided by the university to those needing assistance in developing their hydraulic models for channel modification or FEMA review.

Development of the historical data base appeared to be a logical first task from which the additional goals would follow. The most likely source for the historical information seemed to be the data base developed by the Corps of Engineers during the FEMA studies conducted for the area in the 1970s. However, to everyone's dismay, all that remained from the original work were bound copies of the original input and summary output. The initial task suddenly grew from the uncomplicated copying of a tape to the enormous task of transcribing in excess of 5 million characters and attempting to verify that the new results matched the old. Nonetheless, it was still felt that the potential benefits outweighed the cost, so work began.

While the data base was being redeveloped, other members of the project began acquiring the latest HEC models and converting them to the university's UNIVAC 1100 mainframe computer. Although the HEC programs had been configured for a UNIVAC system previously, the university's computer operated in a multi-user environment which limited the CPU memory that could be allocated to a single user. Special "runner" programs were developed to aid in file manipulation and output handling in order to allow a user unfamiliar with the operating system to successfully use the data base and execute the HEC programs.
After about six months of transcribing data and installing the hydraulic models, the amount originally budgeted for computer expense had been exceeded by about 200%. Fortunately at about this time the Corps announced that the HEC models were being rewritten for use on microcomputers. Initially, it was felt that the mainframe was still the best system for the project, but as the computer expenditures continued to increase, it became evident that microcomputers could meet the project requirements and, in addition, that most future users of the data base would have microsystems. Thus, it was decided to discontinue work on the mainframe and to purchase a microcomputer system. Once these hardware problems had been addressed, attention was redirected to the verification of output. Since the majority of the output from the old FIS models consisted of summary water surface elevations, it was difficult to determine when the newly entered data matched the old. Compounding this problem were the precision differences in the computers generating the respective output, as well as the HEC-2 modifications that had occurred since the original studies had been completed.

As the project progressed, documentation of work accomplished became another difficult task. In addition to the original documents from the Corps records, hard copies of complete HEC-2 runs were printed as the transcribed data were verified so that future analysis would have the benefit of detailed output in addition to the summary output. Summary sheets for each tributary were developed to record the location of hard copies, soft copies, approved revisions, and discrepancies with the original model. The soft copies were kept on the microsystem hard disk and backed up onto 5 1/4-inch disks and eventually onto a microcassette backup system. A more comprehensive electronic data base is being developed to help manage updates and status reports and to provide quicker access to approved as well as pending revisions.

Another primary objective of the contract between Memphis State University and the city of Memphis was to train the city's engineering staff on HEC-2. The city wanted their engineers to be able to receive input from the developers, assess the relevance of the proposed changes, and validate the intent of those changes. Also, it was felt that the city staff should be able to investigate an entire reach and not just the reach in question.

The purpose of the training program was twofold: first, to train personnel concerning the use of and interpretation of results from the HEC-2 model, and second,
to train those same persons to interpret and validate a request for map amendment. It was imperative that the city and county engineering staff be able to manage the technical aspects of the Flood Insurance Program, particularly in light of the municipalities' legal responsibilities. Consequently, more than just a cursory understanding of the computer system and the hydraulic calculations was necessary. The training included a complete look at the necessary input code, a thorough review of open channel flow equations used for analysis, an investigation of specific energy and critical flow relationships, complete instruction on non-uniform flow theory, and detailed discussion of the standard step method for natural channels. An important part of the training was the development of an understanding of what field information is needed for input into the HEC-2 model. It was repeatedly emphasized that the model was only as good as the field information used to create the model. As a consequence, the special and normal bridge was discussed in light of the detailed bridge and topographic information needed to model flow around bridges. Finally, the fact that the validity of the results from the model was very dependent on the roughness values assigned to the main channel, as well as to the floodplain overbanks, was stressed.

The kind of request received most often by the city was a request for floodway modification through a letter of map amendment. The topography in the Memphis area is rolling to flat delta, and the surface geology is primarily loess deposit with very erodible channel bottoms. The three channels in the Memphis area all have had some form of channel realignment as well as clearing and snagging performed on them within the last 50 years. Some minor dredging is still continuing, since the channels are a source of gravel and sand construction material. Additionally, some dredging is occurring to produce fill material for areas within the floodplain. Consequently, the channel bottoms are very dynamic and unstable. Compounding this problem, when the original model was developed, the cross-sections were sometimes too far apart to accurately model the floodplain, and storage volumes were often unnecessarily restricted. Originally, this was felt to be beneficial, since it provided a built-in safety factor of sorts. But as soon as consultants for some of the developers realized the shortcomings of the original model and as the micro version of the HEC-2 model became more readily available, the city was inundated with requests for floodplain as well as floodway revisions. Initially the requests were sent directly to the Atlanta office of the Federal Insurance Administration for
review, leaving the city and county out of the review process. Some of the requests were approved subject to a guarantee by the city of perpetual maintenance of the subject channel. The city and the county were reluctant to accept this perpetual maintenance responsibility, particularly since they had not had a chance to review the submissions for accuracy.

Summary

Floodplain management in the Memphis area has historically been reactive rather than planned. Although the area has been fortunate in the last two decades and had virtually no major floods, potential disaster still exists. Although the FIS boundaries stabilized the situation initially, development in the basins continues to direct attention toward consistent and comprehensive floodplain management. The city of Memphis has faced this challenge by developing a cooperative agreement with Memphis State University. This relationship provides the nucleus for future research and development of a floodplain management philosophy. The re-establishment of the HEC-2 data base in conjunction with the community's desire for proper floodplain utilization will enhance the process of floodplain evaluation and modification and will help to consolidate efforts to manage floodplains during a time of continued community development.
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MECKLENBURG COUNTY GREENWAYS: A PLANNED OPEN SPACE NETWORK OF FLOODPLAINS

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Introduction

Mecklenburg County, North Carolina has undertaken an ambitious greenway acquisition program to preserve floodplains along more than 20 creeks designated in a Greenway Master Plan. Preservation of selected floodplains as open space will provide opportunities for passive recreation, protect plant and wildlife habitat, and reduce flood damages which historically have averaged $1.4 million annually. The linear greenway network will supplement and link existing and future parks and tie together many neighborhoods, schools, office parks, and commercial areas. Trails for walking, jogging, and bicycling are being carefully designed and constructed to retain the natural character of the floodplains and to minimize long range maintenance costs.

Located in the southern piedmont region of North Carolina, Mecklenburg County is the largest county in North or South Carolina, with a population of 415,000, of which 320,000 reside in Charlotte, the Carolinas' largest city. The completed open space network will form a "green necklace" around the heart of the county (Figure 1). Greenway acquisition and development are administered by the Mecklenburg County Park and Recreation Department.

The Acquisition Process

The Master Plan for Mecklenburg County's greenway was developed in 1980 by a consultant in conjunction with a site selection committee appointed by the Mecklenburg County Park and Recreation Commission. All county creeks were evaluated for inclusion in the system, using a two-state weighted numerical method. In the first level of analysis the following selection criteria were used: population density, linkage, anticipated growth, aesthetics, type of development, and accessibility. Having filtered the number of candidate streams, the second level criteria included 1) amount of adjacent existing public property and 2) geographical equity in the distribution of parks and greenways throughout the county. Streams with higher scores were to be acquired first; lower scoring streams would be acquired in a second phase. Fourteen creeks were designated for first phase acquisition. In practice the
Figure 1
Mecklenburg County Greenway Master Plan
community has exercised opportunities to acquire floodplain on second as well as first phase creeks during the early development of the system.

Existing floodway, subdivision, and zoning ordinances were examined in an effort to find support for greenway acquisition, but none contained provisions directly relating to greenways. An open space requirement for cluster subdivisions has been used to require greenway dedications where applicable. A 20-year generalized land use plan for the county, the 2005 Plan, was completed in late 1985 by the Charlotte-Mecklenburg Planning Commission staff. This plan strongly endorses the greenway program, and, in fact, recommends additional creeks for greenway designation. Planning staff is to revise the subdivision and zoning ordinances this year and will incorporate some specific provisions for greenway preservation.

Greenway acreage has been acquired by purchase with local park bonds and by dedication through the development process. The procedure for greenway purchase will be explained first.

Concentrating on creeks in order of priority recommended by the Greenway Master Plan, a preliminary plan for potential acquisition was laid out using base maps. Property owners were notified by a letter explaining the greenway concept and requesting permission to survey the floodplain portion of their property. The property was then surveyed, mapped, appraised, and purchase negotiations were begun. Fee simple rights were purchased. A greenway variance may have been granted to the property owner if the taking would have infringed on the privacy of a single family home or removed actively farmed land out of production. To date, 24 variances have been granted in a subdivision which was developed prior to the 1972 adoption of local floodway regulation. The single family lots there bordered the creek and were not large enough to accommodate a trail along the creek without loss of homeowner privacy. Fortunately, land was purchased on the opposite side of this creek so that continuity of the trail will not be lost.

Land acquisition through the development process has been very productive considering the lack of existing ordinance incentives. This has been possible because of the support and cooperation of several governmental agencies and boards and will be discussed more fully later in this paper. All requests to rezone or subdivide property that includes potential greenway are referred by planning commission staff to park and recreation greenway staff for comment. Discussion is initiated with the requesting party regarding a greenway dedication. Written comments making a case for dedication are subsequently sent back to planning commission staff
as well as to the elected officials who make the final decisions on rezonings. Dedications from residential subdivisions which do not require rezoning are more difficult to secure. However, a number of developers willingly dedicate land in these cases. Cluster subdivision regulations require a percentage of the property to be retained as open space. This area must be either owned by a neighborhood association or dedicated to the county; we often acquire greenway through this provision.

There are also income tax incentives that encourage some developers and individuals to donate land for greenway. A fact sheet outlining these benefits has been prepared by the Parks and Recreation Department for potential donors in the county.

To date more than 1,075 greenway acres have been acquired. Over 40% of this land has been donated by developers and other individuals. Approximately 300 acres are designated for dedication on approved conditional rezoning site plans and subdivision plats with conveyances to the county to take place at the time the property is developed.

### Agency and Board Cooperation

The success of the greenway acquisition program up to this point is largely the result of two factors: the coordination and cooperation of several governmental departments and the favorable climate created by actions of elected boards. Although the program is administered by the county's park and recreation department, most potential dedications come about through the development process--i.e., rezoning and subdivision--and originate from the joint Charlotte-Mecklenburg Planning Commission. Coordination with planning staff is essential and has been excellent. Similarly, cooperation is necessary between greenway staff and the city and county engineering departments, city and state transportation departments, city and county legal staff, and the joint city-county risk management staff. In addition, several designated greenway creeks will connect or pass through parks within the city limits of Charlotte which are managed by a separate park and recreation department.

Land use decisions on conditional rezonings are made by both Charlotte's city council and the county's board of commissioners. Both bodies have consistently supported decisions which include greenway dedications. A number of developers now offer dedications in situations which technically do not require them in order to gain support for their requests.

Long-range planning for Mecklenburg's greenways involves more than land acquisition. Floodplains are used for sanitary sewer lines, natural gas lines, and overhead
power lines. Greenway trails and utility easements can co-exist with coordinated planning. Roadway design also impacts future greenway development. Trails may pass under bridges with sufficient vertical clearance. At grade pedestrian crossing may require special signals or signs. New roadways or improvements to existing facilities must be monitored so that future greenway continuity and safety are accommodated.

Moving Into the Development Phase

Up to now, the greenway acquisition program has primarily been a land banking operation. A 350-acre greenway park, which preceded the Master Plan, was completed in 1979. The county's second greenway park will be opened to the public in early 1987. The acquisition of floodplain land is relatively low-key compared to developing a greenway on 264 acres abutting eight separate subdivisions with ten pedestrian access points. Public hearings and meetings with numerous individuals and small neighborhood groups are part of the planning and development process in which we are now engaged in preparation for the second greenway park. Slide show presentations as well as brochures and Master Plan maps are part of this public relations effort. It is very important for this greenway to be well-designed and thus acceptable to adjacent landowners. The park will be constructed on acreage donated by developers before many of these homes were constructed. So far, our efforts have been well received, and plans for this new greenway are moving forward.

But we need to continue and increase our efforts to educate the general public in Mecklenburg County about the functions and benefits of the greenway system. Thus, we are currently working with the science curriculum specialist for the public schools to develop educational materials to be used at the elementary and secondary levels. The greenway concept is relatively new in Mecklenburg County and our hope is to develop an educational process that will help future generations appreciate and accept the idea of a planned open space network.

Conclusion

Mecklenburg County's planned open space network has miles and acres to go before it becomes the system envisioned in the Master Plan. The completed network outlined in that plan would incorporate more than 4,000 acres and nearly 60 miles of trails, and additional greenway creeks are recommended in the new 20-year land use plan. With continued growth, acreage is being rapidly added to the system through the
development process. Coordination and cooperation between agencies and boards has been invaluable to the success of this long-range project which will enhance and preserve the special quality of life in Mecklenburg County.

References

PRIVATE SECTOR INVOLVEMENT IN FLOODPLAIN MANAGEMENT

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Background

San Diego County is located in the extreme southwest corner of the United States. The climate is warm and dry, with annual rain near the coast of ten inches. Rivers and streams are ephemeral and subject to extremes of no flow during drought years followed by short periods of large flood flow with high velocity, erosion, and sedimentation as major storms attack the Pacific coast.

With watercourses dry most of the time, stream beds have been used extensively for farming and as sources for construction sand—one of the building materials needed to construct the urban amenities desired by people moving into the area. Watercourses and floodways in San Diego County are both privately and publicly owned. On the upper San Diego River, sand extraction and construction material processing have evolved as the major land use.

San Diego River Floods

The section of the San Diego River discussed in this paper had no floods from 1943 to 1977. An unusually severe drought combined with the construction of two reservoir dams resulted in virtually no surface flow during this period. However, the winter of 1978 produced a major flood. The road crossings at Channel and Riverford Roads were washed out. Riverbed erosion beneath the bridge at State Route 67 resulted in loss of substructure stability and closure of the road. Three major water transmission mains which cross the river were threatened, and a major sewage transmission line was destroyed. Another large flood occurred in 1980 with similar results. The State Route 67 bridge was replaced with a new structure that has a deep, flood resistant foundation.

Floodplain Management

The San Diego County Flood Plain Management Program provides the basis for planning and construction of flood control structures, bridges, and other river improvements. A floodplain and floodway have been defined for the section of the San Diego River considered here. The floodway analysis requires detailed input describ-
ing existing conditions of the river (cross-sections and topographic data describing the riverbed, roads, bridges, etc.) and gives flood information such as velocity and flow distribution. The floodway/floodplain analysis locates areas which would be inundated by a 100-year flood and identifies sections of the river which will be subject to erosion; but it does not provide solutions to flood problems.

The Private Sector

The private and public property owners of the floodway and adjoining land of the Upper San Diego River in the community of Lakeside are associated because of a common interest in gaining protection from flooding. With encouragement and assistance from the San Diego County Board of Supervisors and county staff, the owners, along with representatives of local community organizations, have formed a committee. This committee is promoting a flood control project which has been designated the Upper San Diego River Improvement Project (USDRIP). The project area has been defined, and an alignment and flood control design for the area have been agreed upon.

The USDRIP is patterned after a similar project along a reach of the Lower San Diego River in the City of San Diego (Mission Valley). Dubbed the First San Diego River Improvement Project (FSDRIP), it is nearing the start of construction. All of the land in this project is privately owned. The estimated cost is $25 million, and the financing is being structured in accordance with the State of California 1913 Act Assessment District and 1915 Act Bonds (federal and state tax free) to be repaid by the benefiting private owners within the project area. No public funds will be used. All necessary approvals have been obtained, and development plans for the benefited private property which becomes the security for the bonds have been approved in the form of a Specific Plan, a form of zoning in California; Development Agreements, a form of contract zoning in California, have also been executed by the city and each private owner. The apparent feasibility of FSDRIP—the first major public improvement funded without public money that we are aware of—is a major motivation for the USDRIP committee.

The USDRIP participants recognized the potential value of the land in the project area, if it could be protected from flooding and zoned for private sector development. What is somewhat unique here is that the county and the Lakeside community are working with a formally recognized committee toward a common goal of providing flood protection for a major river.
Flood Control Plan

A feasibility study was recently completed for USDRIP, including cost estimates and preliminary environmental examination. A team of private sector professional consultants conducted the study; however, the alignment, with two options, and the design, with three options, were produced by the County Flood Control Division. The consultant contract was administered by county staff, and the final report was approved by USDRIP before forwarding it to the Board of Supervisors for approval as the Upper San Diego River Flood Control Plan.

A two-mile long flood control project includes five major "drop" structures that average 300 feet in width and 12 to 15 feet in height. A combination of rock and concrete was found to be most effective for four of the structures. Reinforced concrete is proposed for the fifth structure, which will also serve as a foundation for a bridge at Channel Road. These structures will provide energy dissipation so that the floodway between them can be reshaped into a natural channel that will not require erosion protection.

Financing

The participants are currently most concerned about financing. The work is proceeding based on the assumption that little or no public funding will be available. The formation of an assessment district and other redevelopment project methods are being explored simultaneously. Market and traffic analyses are also being done as a preliminary step to the appraisal of potential land values. The consultants' estimates indicate the USDRIP may cost as much as $20 million to construct.

Summary and Conclusion

The two projects described in this paper demonstrate that private sector involvement in all stages of flood control planning facilitates decision making and development of such projects. When the public and private sectors each recognize, understand, and support the role of the other, innovative planning, financing, and construction methods can be found that make possible major floodplain management projects without significant public outlay.
Figure 1
Erosion at Channel Road--1978 Flood

Figure 2
Riverford Road--1978 Flood
Figure 3

Upper San Diego River Flood Control Project

- Proposed Floodway
- Low Flow
- Figure 3
- County Waterline Drop
- Structure I
- Upper San Diego River Flood Control Project
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HOW TO MANAGE FLOODPLAINS WITHOUT AN INSURANCE PROGRAM

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Introduction

The need to manage floodplain lands in the Province of Ontario was emphasized in 1954 when Hurricane Hazel struck the metropolitan Toronto area, resulting in the loss of numerous lives and millions of dollars of damage. On October 15-16, 1954, severe flooding caused by Hurricane Hazel was felt particularly in the metropolitan Toronto area, the most populated part of the province. Since the ground surface was saturated from previous rains when Hurricane Hazel collided with a cold front over southern Ontario, almost all the intense rainfall which resulted went into the watercourses as surface runoff. The area received 8.3 inches of rain in 48 hours. A total of 81 lives were lost, and almost 2,000 people were left homeless. Total damages hit $75 million. Along one section of the Humber River, an entire street called Raymore Drive was swept away. Fourteen homes were gone, with 31 lives lost.

Northern Ontario's worst storm occurred in September, 1961, on Town Creek in the town of Timmins. This was a severe thunderstorm, producing 6.7 inches of rainfall in 12 hours. Five people lost their lives, and there was considerable damage.

To mitigate such disasters, the Province of Ontario has determined its role in the planning and management of floodplain lands to be:

- Providing order and equity in the use/nonuse of floodplain lands, and
- Protecting society, including all levels of government, from bearing the unreasonable social and economic burdens of unwise individual choices.

The purpose of this paper is to discuss how Ontario manages floodplains without an insurance program. In 1976, and again in 1983, the province reviewed the flood insurance program established in the United States and found that the cost of flood insurance at actuarial rates (unsubsidized rates) would be prohibitive. If flood insurance is to be introduced in Ontario at an acceptable rate to the individual, the provincial government will have to heavily subsidize the cost. Furthermore, it was found that Ontario's present practices in floodplain management were effective; they involve establishing land use controls whereby the susceptibility to future flood damages is reduced by regulating new development in flood risk areas.

The federal government carried out a similar review and ruled out a nationwide
Approximate boundaries of the Regulatory Floods

Figure 1
Regulatory Flood Zones of Ontario
insurance program. As an alternative, the Canadian federal government established the National Flood Damage Reduction Program that involves identifying flood risk areas and discouraging new development in those areas.

In order to provide order and equity in the use of floodplain lands, the Province of Ontario has established flood standards that define floodplain limits. A standard is called a Regulatory Flood. Figure 1 shows the province subdivided into three Regulatory Flood Zones:

Zone 1: Flood level corresponding to the peak flow generated by a storm of Hurricane Hazel's (1954) magnitude,

Zone 2: Flood level corresponding to the 100-year frequency event,

Zone 3: Flood level corresponding to the peak flow generated by a storm of Timmins' (1961) magnitude.

The province does recognize the floodway/flood fringe concept, in which certain areas of the floodplain are considered less hazardous than others and thus are more amenable to development. The flood fringe is that portion of the floodplain where development may be permitted, subject to appropriate floodproofing to the Regulatory Flood Level. The floodway is that portion of the floodplain where development is prohibited or restricted.

Furthermore, the province does allow Special Policy Areas--areas within a community that have historically existed in the floodplain and where strict adherence to certain province-wide policies concerning new development would result in social and economic hardships for the community. As a result, site-specific policies are formulated and applied within the defined limits of a Special Policy Area.

Jurisdictional Framework

The Provincial Ministry of Natural Resources, through the administration of the Conservation Authorities Act, R.S.O. 1980, together with the conservation authorities, have traditionally played the foremost role in the overall management of floodplains in Ontario. A conservation authority is an autonomous, corporate organization, established and authorized by Ontario's Conservation Authorities Act to undertake resource management. A conservation authority is formed on the basis of three principles:

• The watershed as a management unit,
• Local municipal initiative and involvement,
• A municipal/provincial partnership.
The Provincial Ministry of Municipal Affairs and the municipalities of Ontario, through the Planning Act, are responsible for land use planning in the province. The Ministry of Natural Resources and the conservation authorities of Ontario act in an advisory capacity to the Ministry of Municipal Affairs and the municipalities on land use matters related to flooding.

The federal government's involvement in floodplain management is centered around the Canada/Ontario Flood Damage Reduction Program. As flood risk maps are completed, the federal and provincial ministers responsible for the program initiate policies to discourage new development vulnerable to flood damage. In such identified flood risk areas, the two governments have agreed not to promote, finance, or engage in new developments vulnerable to flood damage, i.e., no federal mortgage insurance is provided, no federal/provincial buildings are constructed, and no disaster relief is available for structures built after identification of the flood-prone area.

**Ontario's Three Components for Floodplain Management**

Floodplain management in Ontario has been divided into three components, and each addresses different aspects of flooding and related damages.

**Preventative Approach**

The orderly planning of land use and the regulation of development are the key elements of the preventative approach to floodplain management. This approach is cost-effective, helping to ensure that new buildings and structures are not susceptible to flooding, and that upstream and downstream problems do not occur as a result of new development. In addition, under this approach, floodplain lands may be acquired to prevent or eliminate development pressure. However, while such action can eliminate potential damages, acquisition of lands is an expensive option.

**Protective Measures**

The structural approach involves the construction of dams, dikes, channels, diversions, and other flood control works. These works are designed to provide protection to existing communities located in the floodplain. In certain situations, a cost-benefit analysis may indicate that acquisition and removal of buildings from the floodplain are more appropriate than protective works.

**Emergency Response**

The province maintains a Streamflow Forecast Centre which is linked to a network of weather stations, stream and rain gauges throughout Ontario. After a flood, various levels of government provide financial and technical assistance to victims.
However, only essential costs are covered, and these are restricted to primary residences only.

**Implementation of the Preventative Approach**

Over the long term, the prevention is the preferred approach to floodplain management. By effective land use planning and regulation of development, problems relating to flooding can be prevented before they occur.

The conservation authorities carry out flood risk mapping and are encouraged to incorporate the mapping in their regulations. The Fill, Construction and Alterations to Waterways Regulation is a government- legislated regulation passed under the Conservation Authorities Act, allowing a conservation authority to regulate:

- The straightening, changing, diverting, or interfering in any way with the existing channel of a river, creek, stream, or watercourse,
- The construction of any building or structure in or on a pond or swamp or in any area susceptible to flooding, and
- The placing or dumping of fill of any kind which, in the opinion of the conservation authority, might affect the control of flooding, pollution, or the conservation of land.

Prevention is further supported by the province, which encourages municipalities and planning boards to show or describe floodplains in their Official Land Use Plans and to incorporate policies to regulate and manage new development. Furthermore, the province intends to implement a Provincial Policy Statement on Flood Plain Planning—a formal means of letting local municipalities, public agencies, and the general public know what the government's position is on floodplain management. Although intended to have more weight than a guideline, a policy statement does not have the same force as a regulation. However, it does provide provincial control by defining the intent of legislation and creating an appeal mechanism for the public. Once the policy statement is in effect, municipal councils will have to address floodplain planning in their Official Land Use Plans. Municipalities will have to include policies defining types of uses permitted in the floodplains and policies regulating new development in such areas so that new structures do not experience flood damages or create adverse upstream/downstream impacts to existing development.

**Water Management Problems on the Great Lakes**

Extremely high lake levels have caused extensive flood damages along the shores of Lakes Huron, St. Clair, and Erie. Lake levels are currently nearly three feet
higher than average. When winds create an additional surge, inland properties are inundated and suffer considerable damage. In addition, the high lake levels cause the outlets of rivers, creeks, and streams to back up and become more prone to ice jams and spring flooding.

The province has established emergency shoreline management programs which include low-interest loans to private landowners, covering up to 75% of the cost of protective works. The province has established a Shoreline Management Review Committee to investigate long-term approaches to shoreline management. It is anticipated that discussions on long-range options will result in practical, long-term solutions to the various high water problems along the shores of the Great Lakes. In addition, the federal government has established a Great Lakes Water Level Communications Centre, which provides warnings and advice on high lake levels and flooding.

Summary and Conclusions

In summary, a government subsidized insurance program is not required in order to manage floodplains in the Province of Ontario. Rather, the province has focused on a preventative approach to floodplain management. Ontario has found that strong political will, suitable regulations and land use controls, and a positive public information program are effective.

The conservation authorities do regulate fill, construction, and any alterations to waterways, but since this regulation is intended to be permissive, development is allowed in the flood risk areas. However, each application for development is individually reviewed, and specific design requirements must be met that provide protection to the Regulatory Flood Level; any upstream or downstream impacts to neighboring properties must also be assessed. As part of the regulation process, there is an appeal mechanism in the event that the application for development is turned down.

The regulation program of the conservation authorities is further complemented by the land use planning controls of municipalities. A number of municipal councils already show or describe floodplain lands in their Official Land Use Plans and incorporate policies to regulate and manage new development. As Official Plans come up for review, the provincial government will be pressuring the municipalities to incorporate floodplain management, particularly once the Provincial Policy Statement on Flood Plain Planning is in place.
In addition, the Canada/Ontario Flood Damage Reduction Program coordinates federal and provincial agencies. These must now consider floodplain planning when engaging in, promoting, or financing any new development in flood risk areas. In addition, the two governments have agreed not to provide disaster relief to any buildings or structures erected in an area once that area has been identified as having a flood risk.

In conclusion, the Province of Ontario will continue to advocate sound floodplain management through preventative measures. Regulations and land use controls permit the orderly planning of areas at risk and reduce the possibility of loss of life and property damage in the province—all without an insurance program.
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LOCAL FLOODPROOFING MEASURES, EAST BATON ROUGE PARISH, LOUISIANA

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Land Planning Services, Capital Programs Administration,
Maryland Department of Natural Resources

Introduction
Since settlement by Europeans, the Amite River Basin of southeastern Louisiana has experienced flooding that has been a prevalent, recurrent geomorphic process recognized and respected by the local population (USACE, 1930). However, from the 1950s through the 1970s, development in flood-prone areas of the basin, spurred by a booming petrochemical industry, continued unabated, and local government failed to implement concerted floodplain management efforts (Emmer, 1985). Through benign neglect, unwillingness, and/or inability to address the thorny issues of zoning regulations, local government set the stage for dramatic increases in damages associated with periodic Amite River flooding. In addition, the concomitant accelerated storm water runoff due to this urbanization was progressively increasing the timing and magnitude of peak discharges (Izadjoo, 1985).

In 1983, the inevitable occurred—a major flood inundating over 357,000 acres and 5,000 residences and resulting in $172 million in damages in the Amite River Basin (USACE, 1984). This event triggered intense public pressure and became one of the foremost political issues in the region. In response, the State of Louisiana proposed the construction of a large, multipurpose reservoir on the Amite River, upstream of Baton Rouge, costing approximately $130 million (Brown and Butler, 1984).

Because of an unprecedented decrease of oil prices during 1985 and the first half of 1986, Louisiana faces a projected $600 million budget deficit in FY 87. In light of this, the probability of the state being able to appropriate monies for any large flood control project on the Amite River, regardless of its relative merits, is rapidly diminishing. In addition, even if funding for such a project existed, there would be a lengthy implementation period during which residents would still be at risk to flooding.

Local Floodproofing Measures
Because of these problems, the Louisiana Geological Survey initiated a study to evaluate the cost effectiveness and engineering feasibility of floodproofing measures which could be locally financed and quickly implemented in East Baton Rouge (EBR) Parish. The first step involved compiling information about floodproofing measures from existing data. Only measures proven in other areas to be economically sound and
### Table 1
Summary of Floodproofing Measures Determined Practicable for EBR Parish

<table>
<thead>
<tr>
<th>Measure</th>
<th>Maximum Height of Protection</th>
<th>Comments</th>
<th>Approximate Cost*</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EMERGENCY FLOOD PROOFING</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sandbagging</td>
<td>3 ft.</td>
<td>Per 100 lin. ft. (includes man-hrs)</td>
<td>$110 for 1 ft.ht.; $550/2 ft; $970/3 ft; minimal to $10,000</td>
<td>Emmer et al., 1983</td>
</tr>
<tr>
<td>Wrapping</td>
<td>3 ft.</td>
<td>Range</td>
<td>$500 per house</td>
<td>Ill. DOT, Baker et al., 1984b, 1984</td>
</tr>
<tr>
<td><strong>DRY FLOOD PROOFING</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wainscoted</td>
<td>2 ft.</td>
<td>$5/linear ft; $500 for closures</td>
<td>Baker, 1985</td>
<td></td>
</tr>
<tr>
<td><strong>WET FLOOD PROOFING</strong></td>
<td></td>
<td>Range</td>
<td>minimal to $5,000</td>
<td>Ill. DOT, Architect, 1985</td>
</tr>
<tr>
<td>EARTHEN BERMS</td>
<td>5 ft.</td>
<td>Typical House - 1,600 sq. ft. (includes surveying, soils test, closures, etc.)</td>
<td>$11,500/3 ft. ht.; $15,900/5 ft.</td>
<td>USACE, 1984</td>
</tr>
<tr>
<td><strong>FLOODWALL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cinder Block</td>
<td>3 ft.</td>
<td>Per 100 lin. ft. (includes labor, design and misc.)</td>
<td>$1,150/1 ft.ht.; $1,700/2 ft.; $2,300/3 ft.</td>
<td>Emmer et al., 1983</td>
</tr>
<tr>
<td><strong>ELEVATION</strong></td>
<td></td>
<td>Costs dependent on height</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9 ft.</td>
<td>Range-all house types</td>
<td>$3,000 to $42,000</td>
<td>Ill. DOT, USHud, 1977 USACE, 1984</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Typical LA. house (excluding slab)</td>
<td>$3,000 to $14,000</td>
<td>Mobile Home Service Co., 1985</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mobile Home</td>
<td>$300/ft; $2,000 for 10 piers; $500 for reconnections</td>
<td>Mobile Home Service Co., 1985</td>
</tr>
<tr>
<td><strong>HOUSE RELOCATION</strong></td>
<td></td>
<td>Range for houses</td>
<td>$22,000 to $67,000</td>
<td>Ill. DOT, 1984b, Mobile Home Service Co., 1985</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mobile homes</td>
<td>less than $1,000</td>
<td>Mobile Home Service Co., 1985</td>
</tr>
</tbody>
</table>

*--cost does not factor in inflation
feasible to construct were analyzed. Measures determined to be practicable in EBR Parish, including their limits of protection and approximate costs, are displayed in Table 1.

Study Area

Five subdivisions in the Amite River Basin of EBR Parish (Figure 1) were selected to test the cost effectiveness of the floodproofing measures. During the 1983 flood, 187 residences in Cimmaron, Comite Hills, Winchester, and Comite Estates subdivisions and an unnamed trailer park experienced up to five feet of flooding, resulting in $8,834,865 in damages. These communities are representative of the spectrum of house types and possible flooding conditions in EBR Parish. Results obtained, therefore, should be generally applicable to the parish.

Postflood Survey

A detailed survey of house characteristics, flooding conditions, and economic
damage was conducted throughout the Amite River Basin shortly after the 1983 flood (GSRI, 1984). As an example, Table 2 provides a summary of the survey in Comite Hills.

Specific information for houses in the study area--square footage, foundation type, siding type, flooding depth--allows the most appropriate floodproofing measure to be selected for each structure. This information also permits the cost of each measure to be estimated. Specific economic data--structure value and damage, contents value and damage, total damage--allows the cost effectiveness (B:C ratio) of the floodproofing measure for each house to be calculated.

**Application In Communities**

Selection of the most appropriate floodproofing measure to be hypothetically applied to each home was based on characteristics of the house and flooding conditions (such as those provided by Table 2). Basically, this selection used an objective decision tree (Figure 2) developed by the Illinois Department of Transportation (1984a). Using the estimates of floodproofing costs (Table 1) and figures on structural characteristics and dimensions of houses (Table 2), the costs of implementing the most appropriate measures were calculated.

For example, consider a 2500 square foot, brick veneer (BV) slab house experiencing two feet of flooding (see Table 2). The decision tree (Figure 2) determines that a levee or flood wall would best protect the house in this case. The 2500 square

---

**Table 2**

Summary of Postflood Survey--Comite Hills

<table>
<thead>
<tr>
<th>Struct. Type</th>
<th>Sq.Ft.</th>
<th>Depth</th>
<th>Struct. Value($)</th>
<th>Struct. Damage($)</th>
<th>Contents Value($)</th>
<th>Contents Damage($)</th>
<th>Damage($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BV,Slab 3,500</td>
<td>1.0</td>
<td>185,856</td>
<td>60,031</td>
<td>87,352</td>
<td>27,079</td>
<td>77,110</td>
<td></td>
</tr>
<tr>
<td>BV,Slab 2,500</td>
<td>2.0</td>
<td>140,800</td>
<td>51,674</td>
<td>66,176</td>
<td>26,272</td>
<td>77,946</td>
<td></td>
</tr>
<tr>
<td>TOTAL DAMAGE</td>
<td>$317,682</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

BV - brick veneer

(GSRI, 1984)
foot house has a perimeter of 200 linear feet (LF) (building perimeter is approximated by computing the square root of the square footage and multiplying by four). This would require a 250 LF cinder block flood wall built to an elevation of three feet (allows one foot freeboard and at least a ten foot spacing between wall and house). A three-foot cinder block flood wall costs $2,300 per 100 LF (Table 1), making the total cost to protect the house approximately $5,750. Table 3 lists the estimated expenditure for the application of such measures to Comite Hills structures.
Results

From the damage information provided in the postflood survey (as in Table 2) and the cost for each measure deemed appropriate (as in Table 3), the cost effectiveness (B:C ratio) of measures for all five subdivisions was calculated.

A summary of results for each community and the aggregate are shown in Table 4.

Table 3

Cost of Floodproofing Measures--Comite Hills

<table>
<thead>
<tr>
<th>Structure Type</th>
<th>Sq. Ft.</th>
<th>Depth(ft.)</th>
<th>Measure</th>
<th>Cost($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BV, Slab 3,500</td>
<td>3.5</td>
<td>1.0</td>
<td>DF</td>
<td>1,700</td>
</tr>
<tr>
<td>BV, Slab 3,300</td>
<td>3.5</td>
<td>1.5</td>
<td>DF</td>
<td>1,700</td>
</tr>
<tr>
<td>BV, Slab 2,500</td>
<td>2.0</td>
<td>2.0</td>
<td>W3</td>
<td>5,750</td>
</tr>
<tr>
<td>TOTAL COST</td>
<td></td>
<td></td>
<td></td>
<td>$10,150</td>
</tr>
</tbody>
</table>

*BF* = emergency flood proofing;
*DF* = dry flood proofing;
*W3* = 3 foot cinder block floodwall.

Conclusions

Analysis of the data presented leads to several timely conclusions:

1) Given the types of houses and flooding conditions in EBR Parish, local floodproofing measures are feasible and would be a cost-effective method for reducing flood damages.

2) Given the results from Comite Hills, the cost effectiveness of the measures appears to increase greatly as the depth of flooding decreases; it becomes increasingly cheaper to protect against flooding at lower levels.

Table 4

Summary of Results

<table>
<thead>
<tr>
<th>Subdivision</th>
<th>Homes Flooded</th>
<th>Depths(ft.)</th>
<th>Benefit* (Damage($)</th>
<th>Cost($)**</th>
<th>B:C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cimmaron</td>
<td>23</td>
<td>0.0-4.0</td>
<td>858,426</td>
<td>230,700</td>
<td>3.7</td>
</tr>
<tr>
<td>Winchester</td>
<td>4</td>
<td>0.5-5.0</td>
<td>2,721,756</td>
<td>262,300</td>
<td>10.4</td>
</tr>
<tr>
<td>Comite Hills</td>
<td>91</td>
<td>1.5-4.0</td>
<td>317,682</td>
<td>10,150</td>
<td>31.3</td>
</tr>
<tr>
<td>Comite Estates</td>
<td>40</td>
<td>0.0-4.0</td>
<td>4,336,208</td>
<td>978,900</td>
<td>4.4</td>
</tr>
<tr>
<td>Trailer Park</td>
<td>40</td>
<td>0.0-4.0</td>
<td>600,793</td>
<td>149,200</td>
<td>4.0</td>
</tr>
<tr>
<td>TOTALS</td>
<td>187</td>
<td></td>
<td>8,834,865</td>
<td>1,631,250</td>
<td>5.4</td>
</tr>
</tbody>
</table>

*Benefits are for a single flood (1983 magnitude) and do not consider 1) additional savings from recurring floods, 2) savings due to reduced flood insurance premiums in some cases, or 3) savings due to possible property value appreciation.

**Cost figures do not consider 1) possible savings of 10-15% by joint venturing of contracts, 2) maintenance costs, or 3) interest on borrowed capital.
3) For the majority of homes in the Amite River Basin flooded in 1983, conclusion two is significant and encouraging. Over 70% of the homes in the basin experienced low-level (less than three-foot) flooding, similar to that of Comite Hills (GSRI, 1984). The cost-effective results for floodproofing homes in Comite Hills therefore, should be expected for most homes throughout the basin.

**Discussion**

Unquestionably, the most effective means of reducing future flood losses in EBR Parish is to avoid development in flood-prone areas. But for existing homes in flood-prone areas, implementation of local floodproofing measures—such as sandbagging, wrapping, wainscoting, wet floodproofing, levees, flood walls, elevation, and relocation—offer sound, fast, cost-effective, and long-term relief from flood damages.

Specifically, results of this study demonstrate the cost effectiveness of such measures given the house types and flooding conditions of five subdivisions in EBR Parish. These subdivisions are representative of the spectrum of flood-prone subdivisions throughout the Amite River Basin. Similar cost and benefit relationships should therefore be expected for the basin in general.

However, as favorable as these results are, several impediments must be overcome before floodproofing measures can be successfully implemented. These include floodplain amnesia (general apathy and resignation of victims and local government shortly after a flood); limitations of available funds; the public's and local government's lack of awareness or unwillingness to attempt to understand these measures; the reluctance of victims to be inconvenienced or interrupted by implementation of measures; the desire to have the problem solved somewhere else, by someone else, and with that person's money as well; and the public's predisposition to favor large structural solutions, even with the slim possibility of funding for construction.

If these social and economic obstacles can be surmounted, significant floodproofing measures could be implemented in the Amite River Basin. However, for these measures to be truly successful, local government must break the tradition of allowing and blatantly encouraging development of flood-prone areas. A strong and active program of floodplain management will be needed especially when one considers the foreseeable and inevitable increases in runoff that will accompany future urbanization in the basin.
**Status**

State legislators for EBR Parish were encouraged by the results of this study. Cooperative efforts with local government officials are underway to develop local financing to implement the measures.

Potential funding sources include parish taxes or bonding issues, the Statewide Flood Control Program which requires a 30% local match, or local efforts at the civic level (e.g., homeowners purchasing materials and contributing in-kind work with engineering and technical guidance provided by state officials). Given the current fiscal plight of both state and local government in Louisiana, implementation of measures at the civic level appears to be the most realistic avenue for the immediate future.

**Recommendations**

In EBR Parish, presentation of technical data in workshops has proven not to be effective in promoting floodproofing measures or educating the public about flood protection (Emmer, 1983). Therefore, since "nothing works like success," it is suggested that a pilot project demonstrating floodproofing measures in a selected subdivision be attempted. Such a project may strongly promote the acceptance of measures locally.

However, the test subdivision should be selected carefully; choice should not be based solely on cost effectiveness, flood severity, or politics. Implementation of floodproofing measures will be complex and require much involvement and cooperation by residents. Thus, subdivision selection should strongly consider 1) community interest and willingness to participate and 2) involvement by respected community leaders. Without citizen involvement and local leadership, measures could be almost impossible to carry out—especially at the civic level.

State agencies should devote staff to provide technical guidance and engineering expertise. This assistance should not be provided in workshops but in the field, with staff actually supervising construction in the pilot project area.

Additionally, parish officials should investigate floodplain management alternatives to ensure that present flooding problems are not intensified by continued development in flood-prone areas or by further increases in runoff from future urbanization. Such alternatives include changing zoning and subdivision regulations, promoting building designs to account for possible flooding, creating new building codes, developing storm water management/retention systems, acquiring land rights,
legislatively open space zoning, promoting emergency preparedness, developing flood warning systems, and instituting public information/education programs.

Acknowledgment

The majority of the research upon which this paper is based was performed by Mike D. MacDaniel. Dr. MacDaniel deserves both thanks and much respect for his unselfish commitment to solving the many flooding problems of the Amite River Basin.

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U.S. Department of Housing and Urban Development

U.S. Army Corps of Engineers (USACE)

STANFIELD: A CASE FOR COOPERATION
OR, ORGANIZING A SMALL TOWN TO FIGHT AN EXTREME FLOOD HAZARD

Steve Randolph
Umatilla County Planning Department, Pendleton, Oregon

Introduction

Stanfield, Oregon, is located at the mouth of Stage Gulch, a major tributary of the Umatilla River in the semi-arid Columbia Basin of the northeastern part of the state (Figure 1). The town was platted in 1910 on the flat valley floor, bounded by low bluffs to the north and south and the mainline of the Union Pacific Railroad elevated on an embankment across the valley to the west. The railroad thus protects the town from flooding by the nearby Umatilla River but conversely serves as a dam, trapping runoff from the 117 square mile Stage Gulch watershed to the east.

Stanfield developed as the service center for a small irrigation project and has in recent years grown rapidly as a bedroom community for workers at the nearby rail yard, potato processing plants, and large irrigated farms. The downtown shopping area, two schools, all community facilities, and the homes of fully two-thirds of the 1655 inhabitants are located in the 100-year floodplain of Stage Gulch, with most neighborhoods lying four to six feet below the 100-year flood elevation.

Flooding in Stage Gulch occurs in the winter and early spring when warm chinook winds or warm, rainy storm fronts cause rapid melting of snowpack lying on frozen ground. Major floods occurred in 1979, 1964, 1949, and earlier. However, particularly in recent times, minor flooding has developed or threatened to develop each year. Two major irrigation canals encircle the town along the bluffs and on occasion also cause flooding.

Within the town, Stage Gulch Creek has been channelized between earthen levees, creating a feature locally known as "the ditch." The capacity of this channel under ideal levels of maintenance is only about 500 cfs, or about a 10-year flood, but the ditch has seldom been properly maintained. In 1985, it could only accommodate about 250 cfs and had to be sandbagged to prevent flooding in town.

Following a 50-year flood in 1964 and a major flood in 1979, the city requested that the Corps of Engineers upgrade the channel. The Corps did clean out the ditch in 1965; however studies in 1976 and 1981 revealed that the costs of improving the ditch to accommodate a 50-year or 20-year flood would result in negative benefit-cost ratios that would preclude federal funding. Needless to say, this created quite a stir in the community since about a half million dollars in damages occurred during both the 1964 and 1979 floods.
Figure 1
Stage Gulch Watershed

Location Map

Umatilla County, Oregon

Stage Gulch Watershed

(USDA, Soil Conservation Service)
Floodplain Management Plan

At the request of the city, FEMA commissioned a Flood Insurance Study for Stanfield that utilized hydrologic information generated by the Portland District Corps of Engineers office during its 1981 study. This second study was completed in early 1984. The potential magnitude of a 100-year flood on Stage Gulch, never before realized by the community, was enormous. The new floodplain boundaries included twice as much area as that covered by the 1964 flood, the largest event most people recalled. The depths of a 100-year, 1,930 cfs flood, amazed the city--four to six feet downtown and up to eight feet in a few places.

As part of Oregon's state-mandated comprehensive planning program, Stanfield adopted over two pages of floodplain management policies in its 1983 revised Comprehensive Plan, following review of the preliminary FIS and lengthy discussions with Region X FEMA staff. Then, as part of its new 1984 Zoning Ordinance, the city set up two flood hazard overlay zones, one for the 100-year floodplain, the other for the floodway. Also, much of the floodway was designated "Permanent Open Space" and zoned for agricultural use. The standards to be maintained within these zones are quite detailed and exceed those required by the NFIP. The following are a few of the more unusual features:

- When key bridges are repaired or replaced, they must be redesigned to accommodate the 100-year flood flow.
- Landfill may be placed on a maximum of 35% of the site area.
- Permits are required for fences, free-standing walls, dikes, and hedges.
- Principal new structures are approved only after a public hearing and mailed notice to neighbors, FEMA, and the state floodplain coordinator.
- Backflow valves are required on new water and sewer installations.
- Wet floodproofing is required for small accessory buildings in lieu of elevation.
- Mechanical systems must be installed above the 100-year flood elevation.

The new floodplain management policies provide a framework for development of a flood control plan; they call for actions to be taken and are not just regulatory guide-
lines. For example, they require the city to actively plan for or negotiate for replacement of the bridges across Stage Gulch. Removal of a dangerously situated trailer park, development of a ditch maintenance program, and removal of obstacles in the ditch and floodway are now also part of the official city plan.

Since this regulatory program has gone into effect, the city has developed hands-on experience in assisting homeowners and developers in designing buildings, mobile home installations, bridges, and even backyard fences to meet the new standards. A successful fight with the U.S. Postal Service resulted in a downtown location for the new post office, which has become an attractive and affordable model of flood-resistant construction. A new bank has also taken exemplary floodproofing measures.

The 1985 Flood

On February 11, 1985, Stage Gulch crested as snowpack melted on ground that had been deeply frozen during a snow-free period that winter. Upstream, about three miles from town, the channel crosses two main irrigation canals at grade. The bulk of the water flowed into these canals, filling them with silt, and causing them to overtop their banks miles from the Stage Gulch channel. Distant rural houses were flooded and several miles of canals were choked with mud. Downstream, in the early hours of the morning, city residents and volunteers from nearby communities sandbagged the ditch and thus prevented all but minor spills along the channel. Following the flood the irrigation districts resolved to construct adequate floodgates on their canals, leaving the city facing a serious dilemma. The canals had diverted 350 cfs, leaving only 250 cfs to flow through town. If the canals had been sealed off, all the water would have descended on Stanfield, overtopped the ditch banks, and left at least two feet of water over most of the city. Yet the flood was only about a 15-year event.

Obviously, the ditch needed cleaning to restore its original capacity, but it quickly became apparent that even a clean channel would not have protected the community from the 1985 flood. With the help of Bill Porfily, manager of the Stanfield Irrigation District, the city organized a large volunteer effort, and thanks largely to the donation of heavy equipment and operators by the irrigation districts, the ditch was renovated. Then during the summer and autumn, crews built new floodgates and a wide, shallow 100-year flood channel for Stage Gulch upstream from the city.
The Stage Gulch Project

With the prospect of no upstream floodwater diversion and an "expressway" flood channel leading to the old, narrow ditch, the city appealed to FEMA and the newly-established state floodplain coordinator's office for help. Carl Cook of FEMA and Dave Maurer of the state office met with city officials and discussed Stanfield's short-term problems, funding possibilities, and most importantly, the comprehensive nature of the flooding issue on Stage Gulch. Agricultural practices, upstream erosion, and sedimentation were pointed out as major contributing factors to Stanfield's flood susceptibility—not just the undersized channel through town. They suggested a multi-agency meeting and field trip to explore the problems further and to discuss all possible funding approaches.

Maurer and Gene Sturtevant of the local Resource Development and Conservation District office coordinated this meeting, which occurred on July 11, 1985 with representatives of all affected federal, state, and local agencies in attendance. The group consensus was that the Soil Conservation Service (SCS) Small Watershed Program was the ideal approach to flood control on Stage Gulch, because both upstream land treatment and downstream flood channelization could be accomplished under one funding package. It was also recommended that a task force composed of watershed residents and local agency representatives be formed to guide the conservation and flood control efforts and to insure a watershed-wide perspective.

In August, the city petitioned Umatilla County and the local Soil and Water Conservation District (S&WCD) to act as sponsors of a small watershed project and to form a Stage Gulch Task Force. This was accomplished and the S&WCD became the lead agency. Henry Kopacz, director of the S&WCD, was appointed to chair the Task Force, which was composed of farmers from several upstream areas, board members of the two irrigation districts, Mayor Martuscelli of Stanfield, and a county commissioner. At their first meeting, the group officially authorized the SCS to conduct an initial assessment of the feasibility of a small watershed project.

In December the SCS reported that the land treatment portion of the small watershed project was indeed feasible for Stage Gulch, but that flood control work through Stanfield again failed to meet federal benefit-cost requirements. (Had the project been proposed a year earlier, both the conservation and flood control aspects might have met the federal criteria then in effect. However, in the interim, standards had been raised.)

At the January, 1986, meeting, the task force again endorsed the small watershed
approach and recommended that the S&WCD continue their work by applying for first phase planning funding. However, the farmers had serious reservations regarding their financial ability to participate in cost-sharing conservation practices—particularly given the state of the local and national farm economy. Therefore a special status for the Stage Gulch project will be sought in order to obtain higher government monetary participation. This effort may be successful, since Stage Gulch was recently declared the number one priority conservation project in the state.

The land treatment program alone is not the answer to Stage Gulch flooding problems, but it will eventually reduce the peak intensity of flows as well as their total volume by trapping perhaps as much as 10% of the runoff upstream. The actual effectiveness of the terraces, sod drainways, check dams, and conservation tillage practices that will undoubtedly comprise the land treatment package will depend greatly upon soil and snowpack conditions as well as upon actual weather patterns during critical flood hazard periods.

That flood control measures downstream, in Stanfield, will still be necessary is recognized by all involved. In fact, local SCS director, Don Greiner, expressed his concern that flood control would not be included in the project, and urged the city to continue its efforts to develop flood control works. He was hopeful that at some future date, under different funding standards, these measures might be reincorporated into the small watershed project.

The city has once again turned to the Corps of Engineers for help—this time in preparing a flood control plan. Through a technical assistance project, the city is hopeful that Bill Akre, of the Corps' Portland Office, working with FEMA and Jim Kennedy, the new state floodplain coordinator, will be able to prepare a technical flood control plan that can be divided into phases and implemented by the local community. The concept the city has proposed is to utilize a variety of funding sources to obtain the right-of-way necessary for a 100-year flood control channel, to work with the County Road Department and State Highway Division to secure replacement of the road and highway bridges using various state/federal/local matching programs, and to construct a flood control channel utilizing irrigation district equipment and volunteer labor—all under the supervision of the city engineer. The Union Pacific Railroad bridge remains a problem that may not be solved until the railroad adds tracks to its main line in the future.
Conclusion

After years of worrying, studying, and inaction, the combined rural and urban communities are actually moving toward a solution to the Stage Gulch flooding problem. There are many players and diverse interests, and it will be the role of the Stage Gulch Task Force to keep things moving in the right direction. The chances for significant mitigation have never been greater, nor the flood threat more severe.
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FINANCIAL ASSISTANCE FOR LOCAL FLOOD CONTROL MAINTENANCE

Jerry Louthain
State of Washington Department of Ecology

Background

The word "maintenance" is usually not associated with anything very exciting or inventive, but I believe that the State of Washington has developed a truly novel approach to maintenance that involves structural and nonstructural measures for floodplain management as well as strong comprehensive planning.

The Washington state legislature has recently significantly modified a law, originally enacted in 1941, that permits cost sharing with local government in the construction of facilities for flood control maintenance. Typical projects have included installing rock riprap on eroding stream banks or on failing existing riprap or levees. Originally, funding was based on a legislative appropriation each biennium with the amount varying from a maximum of $2 million per biennium to no funding for approximately the last ten years.

Over the years the state contributed over $10 million towards projects that totalled over $30 million. With the reduction and ultimate elimination of state funding for maintenance work, maintenance of our stream banks and coastal areas has suffered. Local governmental entities do not have the resources to provide the necessary maintenance on their own.

One of the criticisms of the 1941 legislation and the flood control maintenance program developed to implement this legislation was that the specific projects were only considered a "band-aid" approach to the overall problem. This legislation did not contain any planning requirements, such as evaluating the effect of a specific project on upstream or downstream locations or on the opposite river bank. Instead, projects were considered on their individual merit. In addition, there were no requirements to develop in advance a plan which could be used for comprehensive evaluation of the needs of an entire basin or portion of a basin.

The development of new legislation was based in part then, on the need to protect the investment of state and local funds used for the protection of stream banks and coastal areas. It was also obvious that preplanning of projects in a comprehensive manner was necessary, and that the use of only structural measures to reduce flood damages was not succeeding. Moreover, flood damages have been shown to be increasing more rapidly than corresponding expenditures for structural measures. The implementation of the National Flood Insurance Program in 1968 and the associated required local floodplain management ordinances as a nonstructural means of reducing
flood damages was clearly a step in the right direction.

New Legislation

The state legislature amended the 1941 law in 1984 to address the issues previously identified as problem areas. The 1984 legislation was modified somewhat in 1985 and again in 1986 to make the law more effective. Since a portion of this law has been in effect for two years and a portion less than a month, we are at different stages in program implementation.

The primary elements of the current law are:

1) Funding

A flood control assistance account was established with $4 million as the initial appropriation for the current biennium. At the beginning of each succeeding biennium, the account is re-established at $4 million.

2) Eligible Applicants

Counties, cities, and other local municipal corporations with flood control responsibilities such as flood control districts, diking districts, etc. are eligible to receive state funding for their flood control maintenance projects.

3) Eligibility Requirements

To address the concern regarding the "band-aid" approach of this program, two significant eligibility requirements were established. These concerned floodplain management activities and comprehensive flood control management plans.

A) Floodplain Management Activities--In order for a governmental entity to receive funding for flood control maintenance projects, the Washington Department of Ecology must have approved the floodplain management activities of the county, city, or town having planning jurisdiction over the project area. The Department of Ecology is also required to adopt rules concerning these floodplain management activities to ensure that they are adequate to protect development from flood damages and to restrict land uses within the floodway to only flood-compatible uses. No state funding is provided for floodplain management activities.

B) Comprehensive Flood Control Management Plans--To date, the requirement for the development of a comprehensive flood control management plan has been by far the most interesting and challenging part of this program. Nearly everyone involved with the program agrees that this is an essential element, but since no one has seen a "comprehensive flood control management plan" before, there are many diverse ideas as to what it should contain.
The legislature provided some direction by specifying the following:

A comprehensive flood control management plan shall determine the need for flood control work, consider alternatives to instream flood control work, identify and consider potential impacts of instream flood control work on the state's instream resources, and identify the river's meander belt or floodway.

In addition, the legislation specifies that the comprehensive plan must include the area where the proposed project is located.

Since there was an immediate need for specific flood control maintenance projects in many areas, and since comprehensive flood control management plans are a new concept, the legislation allows up to three years for completion and adoption of a plan from the date of submittal of an application for a specific project. For specific project applications, the county engineer must certify whether a comprehensive plan has been completed and adopted or is being prepared. Comprehensive plans must be prepared and adopted by the appropriate local authority and be approved by the Department of Ecology.

One of the key elements of the legislation passed in 1986 was the provision for state funding of up to 75% of the cost of preparing a comprehensive flood control management plan.

4) Nonemergency Projects

The legislation specifies in somewhat general terms the type of maintenance work that is considered eligible, i.e., work "maintaining and restoring the normal and reasonably stable river and stream channel alignment and capacity . . . and . . . restoring, maintaining, and repairing natural conditions, works, and structures." In addition, state participation can include "restoration and maintenance of natural conditions, works, or structures for the protection of lands and other property from inundation or other damage by the sea or other bodies of water."

All projects must be for public benefit, not for strictly private interests. Projects for individual land owners are therefore not eligible unless there are some adjacent facilities in jeopardy which are owned or operated by a county or other municipal corporation.

5) Emergency Projects

The legislation specifies that a portion of the $4 million be reserved for emergency purposes. Emergency projects are those that must be undertaken immediately to provide protection to life and property.
6) Consultation with Fishery Agencies

Fish, primarily salmon and steelhead, are a key resource that must be taken into account when performing any activity within the waters of the State of Washington. The loss of fish habitat as a result of construction in and adjacent to rivers has been identified as a major concern by our fishery agencies and Indian tribes. Obviously, in the extreme, the most efficient channel for carrying flood waters (perhaps a concrete-lined, flat-bottomed channel) provides essentially no fish habitat.

To ensure that this valuable resource is maintained, the legislature gave review authority to the state departments of Fisheries and Game for all phases of this program. In addition to providing approval for work in and adjacent to waters in the state, the departments of Fisheries and Game must also be consulted regarding plans for specific projects, floodplain management activities, and comprehensive flood control management plans.

Administrative Rules

As with most other state laws for which our agency is responsible, we have adopted administrative rules for the administration of this program. In this instance, because of the responsibility placed on county engineers associated with this program, an ad hoc committee composed of county engineers, county planning officials, and the state resource agencies was formed to develop the administrative rules.

Some of the key aspects of the current rules are:

1) Floodplain Management Activities

The primary guideline that has been included in the rules which was not specified in the law is that to be eligible for funding the appropriate local authority must be participating in the National Flood Insurance Program (NFIP) and be meeting all NFIP requirements.

2) Funding Limits

The $4 million biennial appropriation is broken down as follows: $3.4 million for nonemergency projects, $5.5 million for emergency projects and $.1 million for administration of the program. A limitation of $500,000 per county for nonemergency projects and $150,000 for emergency projects is also specified.
Current Status

We currently have approximately 110 grant agreements for nonemergency projects, totaling $3.4 million. We also have ten grant agreements for emergency projects for a total of approximately $260,000. The agreements are with 46 different applicants in 20 of our 39 counties.

The majority of the projects in which we have participated have not required immediate corrective work. On these nonemergency projects, state funds have covered 50% of the project cost with the local sponsor providing the other half. All funding is on a cost reimbursable basis as specified by a grant agreement between the state and the county. If the applicant is a city or other local municipal corporation, the county prepares a subagreement with the applicant. A final inspection is performed prior to final payment for the work.

Projects we have been involved in include channel clearing, levee and channel structure repair, stream bank protection, vegetation control, sea wall or tidal control structure repair.

Movement of river gravels through stream systems occurs in many of the rivers in Washington. Deposition of gravel results in decreased channel capacities, erosion of stream banks, and the buildup of gravel bars. Many of our projects are related to this problem; several examples occur on the Puyallup River. The headwaters of this stream system drain the entire north flank of Mt. Rainier with a total drainage area of approximately 1,000 square miles. The Puyallup River discharges into Puget Sound at the City of Tacoma. Recorded flows range from a low of 300 cfs to a high of 57,000 cfs. Maintaining channel capacity despite the extremely high bedload and high variability in flow while at the same time minimizing adverse impact to the fishery resource presents a major challenge to all involved agencies.

Several emergency projects were undertaken during last winter's flood season, ranging from stream bank and levee protection and channel clearing projects to the breaching of an unsafe dam and the restoration of the stream channel to its previous condition. The state currently provides 80% of the cost of emergency work, although no maximum percentage for emergency projects was specified in the legislation.

No comprehensive flood control management plans have been submitted for approval by the department at this time.

Proposed Direction

Because of the relatively short time this program has been in place, its lessons
are not yet clear. At this time only one person is assigned specifically to this program. We have learned that this is not going to be sufficient as the program continues to develop, and we have requested one additional person. Funding for administration of this program comes from the $4 million per biennium appropriation. As mentioned earlier, our current rules contain a provision that a maximum of $100,000 per biennium can be used for administrative purposes. One of our proposed revisions to the existing rules will be to eliminate this limit so we can adequately staff the program. In addition, our proposed rule changes will incorporate the changes made during the 1985 and 1986 legislative sessions. Because this program is still partially in the development stage, and because of its many different elements--including comprehensive planning, floodplain management, and structural measures--we feel there is a need to develop a multidisciplinary team to deal with all facets of the program.

As already mentioned, one of the most significant features of this legislation is the requirement for comprehensive flood control management plans. We plan to devote a great deal of effort to refining this process, particularly within the next year. With state funding now available for the development of comprehensive plans, local interest has definitely increased. Thus we feel we need to prepare criteria to use in our review and approval process regarding these comprehensive plans. These criteria will be provided to local governments preparing plans. Once we have reached an agreement with the locals on the guidance they need for developing their plans, we feel that the program will be well on its way to success.
DEFEND: DAM EVALUATION FOR EMERGENCY NOTIFICATION DIRECTION

Bob Smith and Dottie Nazarenus
City of Fort Collins, Colorado

Introduction

In the predawn quiet of July 15, 1982, high in Rocky Mountain National Park, Colorado, a 26-foot high earthen dam breached due to a piping failure and discharged 18,000 cfs of water into the Roaring River. Area campers described the wall of water as a "wet, brown cloud, 25 to 30 feet high, sounding like continuous thunder." When the flood was finally contained four hours later and 12.5 miles downstream in Lake Estes, three people had been killed, a second dam destroyed, and $31 million worth of damage done.

Fort Collins, Colorado, located along the front range of the Rockies in northern Colorado, is ten minutes from Horsetooth Reservoir, which could discharge 100,000+ cfs on the city should any of its five dams fail. The reservoir is too big and too close for Fort Collins officials to adequately warn residents. However, there are 106 other reservoirs within a 50-mile radius of the city, and officials could develop warning systems that would save lives and property in the event of the failure of any of these dams. This possibility was the basis for our study.

The history of this semi-arid, agricultural area 60 miles north of Denver displays significant dependence by local residents upon stored water to assure good yields from rich farm land. A complicated network of reservoirs and irrigation canals divert, store, and then deliver mountain snow melt to the plains during the hot, dry summers. Significant inundation could occur from 24 of these reservoirs and 13 others could cause local flooding, but not to the extent of endangering lives or property. The Fort Collins Stormwater Utility staff decided to assess the impact of each of these reservoirs, and to provide a document to emergency services personnel that would not only advise them of life-threatening situations, but also of less critical possibilities.

Technical Process

The project began in 1985 with four essential items:

1) An inventory of the dams in Larimer County,
2) USGS maps,
3) A personal computer, and
4) LOTUS 1-2-3 software.

All work was identified, organized, and completed by an administrative employee with
technical assistance from the engineering staff. Utilizing procedures developed by the state engineer—and basic data from the inventory including height of the embankment, spillway freeboard, crest width, crest length, normal reservoir capacity, and reservoir surface area—a Qp, or peak discharge hydrograph, was calculated for each reservoir. Erosion potential of the embankment was estimated from a table that provided values ranging from .5 for rock fill with a tight clay core to 1.25 for sand and silty sand.

In all cases, the following three assumptions were made:
1) Reservoir waters were stored to the crest of the emergency spillway,
2) Each dam failed at its maximum section, and
3) In most cases, downstream dams also failed.

The outflow failure hydrograph was assumed to be an isosceles triangle with the following characteristics:

![Graph showing isosceles triangle with Qp, Qcfs, T, and time, hours.]

Base time T represents the time required to fully drain the reservoir.

The next step was to calculate the Qr, or routing loss anticipated as the peak flood proceeds downstream. The method of successive averages, which recognizes that the degree to which routing occurs is a function of length of the reach, channel slope, channel roughness, channel geometry, and base time of the failure hydrograph was utilized. Again, three basic assumptions were made for each reservoir:
1) Peak is reduced,
2) Base time is increased, and
3) Hydrograph shape becomes more rounded.

The resulting changes in the hydrograph are shown below:
Because of the variety of elevation and terrain for all the reservoirs, four typical cross section models were developed for application with the routing steps:

- **Continental Divide:** $S=100\ \text{ft/mile}$, $b=10\ \text{ft}$, $s=8:1$, $n=0.055$
- **Mountain:** $S=60\ \text{ft/mile}$, $b=10\ \text{ft}$, $s=10:1$, $n=0.045$
- **Foothills:** $S=22.2\ \text{ft/mile}$, $b=10\ \text{ft}$, $s=50:1$, $n=0.040$
- **Plains:** $S=15.8\ \text{ft/mile}$, $b=10\ \text{ft}$, $s=100:1$, $n=0.035$

(where $S$ represents the valley slope, $b$ the channel bottom, $s$ the valley side slopes and $n$ the Manning's roughness coefficient).

As a comparison, a water depth of one foot in the steep, narrow Continental Divide channel contained 48 cfs while the flat Plains channel had 166 cfs. USGS maps, and in some cases our own floodplain maps from the various basins, were used to determine the direction the flows would follow as well to estimate the distance to city limits. For each reservoir, we knew the quantity of water that would be discharged during a dam breach, the routing loss in the floodplain, the cubic feet per second that would reach Fort Collins, and how long it would take to get to the city.

**Manual Preparation**

To display the information, a format page was designed with key information at the top and a map covering the rest of the page. Figure 1 shows the information for Douglas Reservoir, one of the "high hazard" dams that would cause major flooding of the Dry Creek basin and Poudre River through Fort Collins. A city street map was used to show in some detail the expected flood area.

Figure 2 provides information for the North Gray Reservoir which is east of the
city. Although a flood in excess of the 500-year storm occurring along Boxelder Creek would affect Interstate 25, this area, at the present time, is not within the city limits.

The pages were color coded and separated into two sections with the pink pages in the first section dedicated to high hazard dams. Cross references were also provided in the table of contents because some reservoirs had more than one name. A draft copy was then sent to each reservoir owner with a request that the information be verified. Most owners could not verify the technical data, and some were concerned that the study was critical of the condition and maintenance of the reservoirs. Nevertheless, owners and representatives of 38 reservoirs visited the Stormwater Utility office and provided assistance and information.

Summary

Our DEFEND Manual will not be of much help should one of those five dams at Horsetooth Reservoir fail because, as mentioned earlier, the reservoir is too close and too big. The manual could, however, help people and property downstream and should certainly serve as a useful reference for emergency services personnel from both the city and Larimer County. They intend to prepare standard operating procedures to be used in conjunction with the manual.

The Fort Collins Storm Utility office is now much better prepared to react to a dam failure at any of the other 106 reservoirs that surround our city. In becoming more knowledgeable about our total environment and establishing positive working relationships with water storage and irrigation company personnel, we have become more sensitive to the potential threat and have also become better floodplain managers.
RESERVOIR NAME: Douglas Lake
EMERGENCY CONTACT PERSON: Bill Johnston
TELEPHONE: 492-7671
LOCATION OF THE DAM: 5.5 miles N of Ft Collins
TRAVEL TIME TO FORT COLLINS: 1.8 hours
FLOW AT CITY LIMITS: 23,600 cfs
IMPACT ON FORT COLLINS: Flows into Dry Creek with flows in excess of the 500 year storm. Major flooding of the basin will occur.

**DOUGLAS 5.5 MILES**

![Map of Douglas Reservoir](image)

Figure 1

Information for Douglas Reservoir as Presented in the DEFEND Manual
RESERVOIR NAME: North Gray
EMERGENCY CONTACT PERSON: Bob Ochsner
TELEPHONE: 462-4670
LOCATION OF THE DAM: 2.8 miles NE of Ft Collins.
TRAVEL TIME TO FORT COLLINS: Monitor Boxelder - 1 hour
FLOW AT CITY LIMITS: None
IMPACT ON FORT COLLINS: Flows into Boxelder Creek. Major flooding of the Creek will occur with flows in excess of the 500 year storm.

Figure 2
Information for North Gray Reservoir as Presented in the DEFEND Manual
COMPUTER METHODS FOR RESIDENTIAL BASEMENT DESIGN WITHIN A DESIGNATED FLOODPLAIN

Clark D. Rusco
City of Great Bend, Kansas

Introduction

Enforcement of floodplain regulations has become routine in Great Bend, Kansas. The regulations, however, were not as well understood six years ago. The evolution of floodplain management began in 1976 when the flood-prone areas within the community were identified. Subsequently, a Flood Insurance Rate Map (FIRM) was published in 1981, and all FIRM appeals were finally resolved in 1983. The city has been in the regular phase of the National Flood Insurance Program since 1983.

Great Bend has a population of 17,000 and is located in central Kansas near the confluence of two creeks and one major river. The city was first settled in the mid-1800s. One reason for settlement in the area was the abundance of groundwater. The topography, however, is very flat, and the floodplain is very wide. Presently, three-fourths of the city is located in a designated floodplain.

Following the adoption of a floodplain management ordinance, a major conflict arose between the requirements of floodplain management and customary building construction practices. The typical home prior to floodplain management regulations included a basement below the natural ground level. Basements are considered desirable because they provide protection from severe weather and energy savings for the earth sheltered housing.

Presently the NFIP requires a variance to be issued to a community before a basement can be constructed in a floodplain. Included in the city's request for a variance to build basements below the base flood elevation (BFE) was the commitment of the city to organize a flash flood warning program for the city.

Basement Variance

The variance to construct basements was requested in June, 1982. Final approval was received in August, 1983. The criteria for floodproofed residential basements were obtained from the Manual For The Construction Of Residential Basements In Non-coastal Flood Environ, published by the NAHB Research Foundation, Inc. for the Federal Insurance Administration (FIA) and the Department of Housing and Urban Development (HUD). The policy of the NFIP was to require a licensed architect or engineer to prepare plans and then certify the structure to be of floodproof construction.

During the first year of the basement policy no homeowner attempted to construct
a floodproof basement. The usual reasons given for not doing so included the high cost of design services and the difficulty and added expense in construction of the basement.

**Floodproof Basement Wall Design**

Subsequently, several minor changes to the HUD manual were submitted to FEMA by the Engineering Department of the City of Great Bend. It was decided that only reinforced concrete basements would be considered for floodproof design, and a design manual was prepared using the design equations from the HUD manual. A spreadsheet computer program was used to calculate the rebar spacing required to withstand the soil and water loadings acting on the basement wall.

The variables entered in the spreadsheet include:

1) Wall thickness
2) \( a \) (see Figure 2 (loaded beam))
3) \( b \)
4) Equivalent fluid weight
5) Concrete strength, \( f'_{c} \)
6) Rebar diameter

A lookup table placed in the far corner of the spreadsheet showed values of \( \frac{M_{u}}{f'_{c} b d^{2}} \) that could then be used to find the corresponding value of the parameter \( w \). Since \( w = \frac{p f_{y}}{f'_{c}} \) the steel ratio \( p \) can be determined (Figure 1).

By entering all the various combinations of variables, a design manual can be generated for all the areas located in the floodplain. A sample spreadsheet output has been included in Figure 2.

The city engineering department then generated a set of standard drawings to be used for the construction of a floodproofed basement. Bar spacings are obtained from the design manual and then inserted in the appropriate areas of the standard drawings.

Another design manual was later prepared using the BASIC computer programming language. This manual covered all the various design requirements for basement walls for the Great Bend area. The variables in the manual include:

1) Design thickness for an eight and ten inch wall;
2) Soil or water load at depths of four, five, six, and seven feet;
3) Ceiling heights of seven, seven and one-half, and eight feet;
### Lookup Table

#### MOMENT STRENGTH $M_u / f_y' c b^2$ or $M_t / f_y' c b^2$ OF RECTANGULAR SECTIONS WITH TENSION REINFORCEMENT ONLY

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\[
M_u / f_y' c b^2 = \omega (1 - 0.59 \omega) = A_f / f_y' (d - a/2), \text{ where } \omega = pf_y' / f_y' \text{ and } a = A_f / f_y' / 0.85 c b
\]

**Design:** Using design load moment, $M_u$, enter table with $M_u / f_y' c b^2$; find $\omega$ and compute steel percentage, $p$, from $p = \omega^2 / f_y'$.  

**Investigation:** Enter table with $\omega$ from $\omega = pf_y' / f_y'$; find value of $M_u / f_y' c b^2$ and solve for theoretical moment strength, $M_t$.  

---

Figure 1
**VERTICAL WALL STEEL DESIGN**

Calculates the structural moment within the wall.

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Calculates the moment capacity of structural member.

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<th>b</th>
<th>d</th>
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Figure 2
Vertical Wall Steel Design
Sample Spreadsheet Output
4) Reinforcing bar size of #4 or #6;
5) Concrete strength of 3000 psi;
6) Equivalent fluid weight of 100 pcf, 120 pcf, and 150 pcf.

**Floodproof Basement Slab Design**

In order to complete the design for a basement, the floor slab requirements must be determined. The structural requirements for a floor slab are dependant upon the magnitude of the buoyancy force. When soil permeability is high, an undrained system must be designed. When the soil permeability is low, however, a drained system can be used.

In the undrained system a buoyant force is present and the floor slab must be reinforced and doweled into the wall. Normally a buoyancy wall is built at the midspan of the floor slab in order to lessen the upward force on the slab.

The soil strata in the Great Bend area generally have a low permeability and a sump pump and underdrain system can be used to lower the groundwater elevation and in effect eliminate the buoyant force acting upward on the slab. Charts are given in the HUD manual to help determine the adequacy of a drained system. The size of the sump pump required can also be determined. Normally, when soil conditions permit, a drained system is more economical to build than an undrained system.

In Great Bend, nearly all soils permit a drained system. Therefore, the slab design consists of a four-inch thick slab reinforced with ten gauge wire mesh on six inch centers.

Some building sites, however, are on highly permeable sand. A sump pump could not handle the large quantity of water that would be present during flood conditions. In this case the buoyant force acting on the basement slab would be large enough to require additional reinforcement.

The design charts prepared for the slab design were based on the HUD manual. The geometry of the slab determines to a great extent the maximum moment in the slab. The geometric coefficient used in the HUD manual was slightly different from those used by the engineering department. The geometric coefficients used for the community's design manual were from *Moments and Reactions for Rectangular Plates*, Engineering Monograph #27, prepared for the United States Department of the Interior, Bureau of Reclamation. The data presented in the manual were computed for five sets of boundary conditions, nine ratios of lateral dimensions, and eleven loadings. The coefficients were developed using the finite difference method.
A computer spreadsheet program is used to calculate the moment in the slab. The inputs required are:

1) Slab size,
2) Slab thickness,
3) Depth of water,
4) Moment coefficients (from Engineering Monograph #27),
5) Concrete strength,
6) Rebar diameter.

Many trials can be performed quickly in order to determine the most desirable solution. Figure 3 contains a sample output for the slab design.

Conclusions

There are many advantages to the local community when specific design drawings and design tables are prepared. If community standards are not used, the design firms located in the area may propose many varied designs. Our community prepared a design in order to standardize and simplify basement construction in the floodplain.

The community's standard design was derived from the HUD manual using the same equations as used in the manual. The HUD manual, however, covered the design of structural plain concrete, reinforced concrete, unreinforced masonry block, and reinforced masonry block. The community's design manual was simplified by only using reinforced concrete.

Design charts can be generated for any community by using a spreadsheet program or by developing a specific computer program. Design charts can be generated to cover only the specific design requirements typical to each community, thus facilitating the rapid design of floodproof structures.

The standard plans used by Great Bend were assembled from the appropriate details contained in the HUD manual. In effect the HUD manual was condensed from a 300-page publication into a 20-page pamphlet of plans and specifications. The plan can be readily explained to a building contractor and can also be used to prepare construction bids when needed.

Contractors and builders now know what to expect when building a floodproof basement. The difference between a conventional basement and a floodproof basement is not great. Normally, the only modifications for a floodproof basement are the waterproofing of the slab and walls, rock for the underdrain system, and a sump pump.
Sample Output for Determining Slab Design
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SUCCESSFUL FLOOD MANAGEMENT ON A REGIONAL BASIS

William G. DeGroot and L. Scott Tucker
Urban Drainage and Flood Control District, Denver, Colorado

Introduction

The Urban Drainage and Flood Control District was established by the Colorado Legislature in 1969 to assist local governments in the Denver metropolitan area with multijurisdictional drainage and flood control problems. Starting with a staff of two and a budget of approximately $400,000 the district has grown, in a carefully planned and well justified manner, to a staff of fifteen with an annual budget of approximately $8,000,000. The history of that growth and a discussion of the key policy decisions which facilitated that growth are given below.

Board of Directors

The district is an independent agency with its own board of directors. If there is a single key to the success of the district, it is the board of directors. The make-up of the fifteen member board is unique; it is composed mainly of locally elected officials who are appointed to the board. Membership includes the mayor, or deputy mayor, of Denver; three Denver city council members; one commissioner from each of Adams, Arapahoe, Boulder, Douglas, and Jefferson Counties; and one mayor from each of Adams, Arapahoe, Boulder, and Jefferson Counties. These thirteen locally elected officials select two registered professional engineers to complete the board membership.

Area

The district includes the City and County of Denver and the urban or urbanizing portions of the five surrounding counties. There are presently 35 cities and counties within the district, which covers an area of approximately 1,200 square miles. Within that area there are approximately 1,200 miles of major drainageways having tributary areas of at least 1,000 acres. The present population of the district is approximately 1.8 million.

Funding

The district's primary source of funds is a property tax; the district is currently authorized to levy up to one mill. Although federal and state funds have been granted to the district in the past, the district does not rely on any other source of funding at this time.

Responsible Growth

The 1969 legislation which established the Urban Drainage and Flood Control
Regional Flood Management

District gave it fairly broad powers but very little money to implement those powers. Initially, the district was authorized to levy 0.1 mill—raising approximately $400,000 for planning and operations.

The first major activity of the district was to inventory drainage basins and sub-basins to determine the extent of problems and to develop a plan to attack those problems. The initial study indicated that approximately 25% of the major drainage way miles within the district were developed, with the remaining 75% undeveloped and amenable to preventive approaches. It was logical that, if effective preventive measures could be undertaken on the undeveloped drainageways, significant savings in future remedial needs could be realized. The district board therefore made a commitment to preventive activities and developed a comprehensive floodplain management program to prevent new problems from being created. The district also realized that the South Platte River, the backbone of the drainage system for the entire Denver metropolitan area, was so large and had so many problems that it could absorb all of the district’s time, effort, and money. Therefore the board decided to emphasize work on the tributaries to the river.

In 1973 the district requested authority to levy an additional 0.4 mill for a design and construction program, and the legislature granted that request, beginning in 1974. Also in 1974, the board established a floodplain management program.

In 1979, the board requested an additional 0.4 mill increase for maintenance and preservation of floodplains and floodways. The legislation passed, although it was limited to taxable years 1980 to 1983. In 1983 that time limit was extended indefinitely. So, by 1980, the district had been authorized to levy up to 0.9 mill for the following purposes: planning and operations (0.1 mill), design and construction (0.4 mill), and maintenance and preservation (0.4 mill).

With several years of experience and many master plans and construction and maintenance projects completed or underway, the district has now tackled the South Platte River (SPR) itself. A master planning study for the SPR was completed in late 1985. Using the master plan as the basis for its request, the district sought an additional 0.1 mill authorization with funds to be earmarked for the SPR, and the 1986 legislature approved that request. The district now has a comprehensive program addressing all aspects of flood management, a set of tried and proven policies and procedures, and a reasonable and reliable level of funding. Details of the individual district programs are provided in greater detail below.
Master Planning Program

The master planning program is funded out of the original 0.1 mill authorization for the district. Key policy decisions which guide program implementation are: 1) each master planning effort must be requested by the local governments and must be multijurisdictional; 2) master plans are completed by consultants acceptable to all affected local governments and the district; 3) the district will provide necessary mapping and will pay 50% of the consulting costs, with the local governments sharing the other 50% of the consulting costs; and 4) the master plan must be acceptable to affected local governments.

After many years of concentrating almost solely on major drainageway master planning, the program has now evolved and broadened to have four major areas of interest: 1) major drainageway master planning, 2) outfall systems planning, 3) drainage criteria manuals for local governments, and 4) special projects, such as criteria for channels and structures on sandy soils, benefit-cost analysis, and wetland issues.

Master plans have provided an important tool for identifying projects for construction. The master plans provide valuable input to the district's five-year capital improvement program. They have also been used on numerous occasions to prevent projects which would have invalidated the master plans or made them much more expensive to implement, and to identify and acquire rights-of-way needed for future improvements.

The program staff consists of one registered professional engineer (PE) and one student intern. There are 46 major drainageway and 15 outfall systems master plans completed or in progress.

Design and Construction Program

Prior to the initiation of the design and construction program in 1974, the board adopted policies that would distribute funds in such a way that local governments would not be concerned that one portion of the district would be subsidizing construction in another portion. The key policy decisions were: 1) proposed improvements must be requested by local governments; 2) proposed improvements must have been master planned; 3) district funds must be matched by local governments; 4) local governments must agree to own completed facilities and must accept primary responsibility for their maintenance; 5) district tax revenue received from each county will be spent for improvements benefitting that county over a period from 1974
to five years into the future; and 6) the district will not develop a public works department but will rely on existing local governments' public works departments.

The district's approach to design and construction is intended to minimize the need for a large staff. Generally the district coordinates final designs prepared by consulting engineers. The local entities are involved in all aspects of the design process. The local entities generally acquire the necessary rights-of-way (ROW) and serve as the construction contracting agency. The district is, however, sometimes the lead agency for ROW acquisition and construction contracting. All costs associated with design, right-of-way acquisition, and construction are shared on a 50/50 basis between the district and the local governments.

Each year the board adopts a five-year capital improvement program which lists projects and district participation by county from 1974 to five years into the future. This plan then forms the basis for district participation in the design and construction program.

The program staff consists of two PEs and one student intern. The program has been involved in construction projects totaling $71 million and involving $31 million in district funds.

Floodplain Management Program

The floodplain management program was created in 1974 to establish a preventive program to keep new problems from being created and to consolidate several activities which had received random attention based on available time. The major activities included in the program are: 1) the National Flood Insurance Program, 2) floodplain regulation, 3) flood hazard area delineation, 4) flood warning, 5) flood damage surveys, 6) reviews of proposed developments in or near floodplains, and 7) public information.

The district's board of directors has authority to regulate floodplains but has chosen not to do so as long as local governments implement their own floodplain regulations. At the same time, the district has assisted many local governments with their floodplain regulations, including assistance with requirements of the National Flood Insurance Program. The district has worked with the Federal Emergency Management Agency (FEMA) not only to assist local governments, but also to attempt to ensure compatibility between floodplains defined by the district and floodplains defined in flood insurance studies. An early and continuing conflict has been the use of hydrology based on projected future development of the drainage basins (the
district approach) versus FEMA's insistence on using existing development to define the hydrology. This conflict continues.

The district continues to identify and publish, through its flood hazard area delineation program, maps of 100-year floodplains in undeveloped or sparsely developed areas so that a defined floodplain will be available for floodplain regulation when development reaches those areas.

The district has been active in assisting local governments in the development of flood warning plans using both spotter and instrumented detection alternatives. In addition, the district retains a private meteorological service to provide forecasts to all local governments within the district of potential flood-producing events, as well as to provide support services in specific flash flood warning plans established for individual drainageways.

In 1976 the board of directors decided to make a special effort to notify occupants of floodplains of the flood potential they face. The result was a program involving the mailing of an informational brochure to each address located in or adjacent to each identified 100-year floodplain. In 1986, 22,000 brochures were mailed under this program.

In 1980, after approval of the maintenance mill levy, the board established a policy which stated that all projects constructed by, or approved for construction by, local governments after March 1, 1980 would have to meet the following conditions in order to be eligible for district maintenance assistance: 1) the projects would have to be designed in accordance with the Urban Storm Drainage Criteria Manual; 2) the plans and specifications would have to be approved by the district; 3) the project would have to be built in accordance with the approved plans; and 4) maintenance access, both legal and physical, would have to be provided. These requirements have been a very effective tool in upgrading the quality of flood control facilities built by developers.

The key policies of the floodplain management program include: 1) active support of the National Flood Insurance Program, 2) non-implementation of district floodplain regulations when local governments are doing an adequate job with their own, 3) annual notification of floodplain occupants of the flood hazard potential, 4) requiring district approval of facilities built by others before those facilities will be considered eligible for district maintenance assistance.

The program staff consists of two PEs. Over 700 miles of 100-year floodplains have been defined by the floodplain management and master planning programs.
**Maintenance Program**

Key policy decisions for the maintenance program include: 1) maintenance of facilities funded by the district shall be the primary responsibility of the local governments; 2) to the extent the funds are available, the district will assist local governments with maintenance and preservation of floodplains and floodways; 3) the order of priority for expenditure of district maintenance funds is: district owned projects, district funded projects, projects funded by others, unimproved urban drainageways, and unimproved rural drainageways; 4) funds derived from the maintenance mill levy are returned to each county in the same proportion as they are received on an annual basis; 5) local governments are not required to match district maintenance funds; and 6) the policy of not creating a public works department is reaffirmed.

The program staff consists of three PEs, two field maintenance supervisors, and two student interns. The annual budget is approximately $3.6 million. All maintenance activities, including design work, are done by private contractors.

**South Platte River Program**

As noted earlier, a 0.1 mill levy has been authorized for the South Platte River beginning in 1987. At the time this paper is being written, preliminary steps are being taken to develop a program. Some issues which must be faced include: 1) the amount of money to be used for capital construction and maintenance, 2) the need for local matching requirements, and 3) the need for an allocation formula for the various reaches of the river. A set of policies will be adopted later in 1986.
AN OVERVIEW OF CANADA-MANITOBA FLOOD DAMAGE REDUCTION AGREEMENTS

Hasu Naik and Derek Bjonback
Environment Canada*

Summary

The Canada-Manitoba Flood Damage Reduction (FDR) agreements are typical of the various types of FDR agreements between the Canadian federal and provincial governments. Since Manitoba was one of the first provinces to join the national program, this case study provides an opportunity to assess the progress of the program in achieving stated goals as well as the management issues that arise in the implementation of these agreements.

Introduction

In Canada, provinces have jurisdiction over their water resources and have an overall legislative mandate except in areas of federal jurisdiction such as navigation, fisheries, and international streams. Therefore, the federal government can only play a supporting role in floodplain management. Initially, floodplain managers in Canada focused their attention primarily on structural measures and disaster assistance as ad hoc responses to flood catastrophes. Escalating flood damages were a prime factor which led the federal government to reevaluate the long-term viability of structural works and disaster assistance as approaches to flood hazard mitigation. A new approach—the Flood Damage Reduction (FDR) Program—was established by the federal government in 1975. Its prime objective was to encourage land use management practices that would incorporate flood hazard information into the planning process.

The FDR program is delivered federally through the Inland Waters Directorate of Environment Canada through cost-sharing agreements negotiated with the provinces and federal territories. These agreements enable the federal government to assist in provincial flood risk management through a broad strategy that integrates flood risk mapping, zoning, and regulation with structural measures. By March 1986, formal agreements had been signed with seven of the ten provinces (Manitoba, New Brunswick, Newfoundland, Nova Scotia, Ontario, Quebec, and Saskatchewan) and the Northwest Territories. By 1985-86, the total commitment under the existing federal-provincial FDR agreements was $79 million, cost-shared almost equally between federal and provincial governments. Financial participation by local governments, generally 10%,

*The views expressed here are those of the authors alone, and not necessarily those of Environment Canada or the Canadian federal government.
100  CANADA-MANITOBA FLOOD DAMAGE REDUCTION AGREEMENTS

is required for structural works.

The Canada-Manitoba Flood Damage Reduction Program

Flooding in Manitoba happens regularly due to spring snowmelt and intense rains; its damage is enhanced by concentrated settlement in flood-prone river valleys. Southern Manitoba, where over 90% of the province's one million citizens reside, is the downstream confluence of several major interprovincial and international rivers including the Assiniboine, Red River of the North, Souris, Pembina, and Winnipeg. The provincial capital, Winnipeg, has sustained major damage six times in the last two centuries due to flooding on the Red and Assiniboine rivers. The largest flood, in 1825, had a 1:670 chance of occurrence. Damage was relatively small then because of the small population. On the other hand, flood losses during the 1950 flood were estimated at $114 million. Flooding of other rivers is not as well documented, but it has been estimated that the average annual flood damage in Manitoba was $14 million before major flood control works were constructed in the 1960s.

Following the 1950 flood, the Manitoba Royal Commission Inquiry was established to examine the feasibility of structural works in the Red River and Assiniboine River basins. Based upon the inquiry recommendations (Province of Manitoba, 1958), the federal government entered into an agreement in 1952 with Manitoba to fund a $100 million program of flood control works. Projects under this program included the Red River Floodway, Portage Diversion, Shellmouth Reservoir, ring-dikes around eight communities in the Red River Valley, and the Assiniboine River dikes upstream of Brandon. In a number of other communities, zoning and land use regulation measures were introduced and temporary dikes were constructed or upgraded as ad hoc emergency flood fighting measures. No uniform policy or standard of flood protection was followed. The new FDR approach therefore presented a good opportunity to bring all these activities under a common umbrella with agreed upon standards and priorities, as well as to establish a better balance between structural and nonstructural measures.

Manitoba was one of the first provinces to join the program by signing, on December 20, 1976, a "General Agreement Respecting Flood Damage Reduction" and two subagreements. The General Agreement states the basic approach and the policies agreed upon by the two governments. The subagreements cover flood risk mapping and floodplain management studies. Additional subagreements for flood forecasting and flood protection works were signed later, based on needs identified during the
implementation of the mapping and studies components. The program cost by component is presented in Table 1.

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+ Includes both federal and provincial share. For Manitoba, planned outlay under the Agreements.
* Studies component included in the Mapping Agreements with Quebec and Saskatchewan. One comprehensive agreement includes all aspects of the FDR program in Ontario.
** $79 million has been committed under the existing agreements.

**Salient Features**

Briefly, the salient features of the Canada-Manitoba FDR program are the following:

1) The General Agreement serves as an umbrella agreement. It outlines a) the basic approach for reducing flood damages, b) policies agreed upon by the two governments and c) the management structure for implementing the FDR agreements.

2) The following operational objectives of the FDR Program follow from the Canada-Manitoba FDR Agreements:

a) Control unwarranted flood damages
b) Identify flood risk areas
c) Inform public of flood risk
d) Provide federal leadership in floodplain management
e) Control development in the floodplain
f) Reduce disaster assistance
g) Coordinate government programs
h) Determine an appropriate mix of structural and nonstructural measures
i) Improve flood forecasting
j) Continue to pay disaster assistance (no action needed)

3) Flood risk areas are identified according to the Flood Risk Mapping Agreement. In Manitoba, the flood risk zone is the area inundated by a 1:100 flood. Where local conditions allow, a distinction is made between the floodway and flood fringe areas within the flood risk zone. The floodway has the greatest flood risk since it is the area with the highest flow and greatest depth. Consequently, development restrictions there are severe. There is less danger in the flood fringe area, so development is permitted provided it is adequately floodproofed.

4) The general public, industry, and government agencies are given information on flood hazards. By increasing the awareness of flood risks, developments in floodplains should be discouraged. Public information tools include 1:10,000 scale multicolor maps, with accompanying background material and explanations. Source materials are based on hydrotechnical reports and 1:2000 scale engineering maps, which are usually not published but are available at cost to interested parties. Flood risk maps and hydrotechnical studies must follow the national cartographic and hydrologic specifications. To satisfy Manitoba's concerns for greater accuracy, efficiency, and economy, Manitoba mapping specifications were adopted in 1982.

5) The identified flood risk areas are formally designated. The Canada-Manitoba FDR Program steering committee recommends designation to both the federal and provincial ministers simultaneously. Those officials then sign the designation order and approve the release of the public information map. Flood risk zones have been designated for 13 of the 24 targeted communities, representing over 62% of Manitoba's population.

6) Post-designation policies include: a) Canada and Manitoba agree not to support or finance flood-vulnerable development in identified flood risk areas; b) Manitoba will encourage zoning at the local level on the basis of flood risk; c) flood disaster assistance will be denied to all new undertakings built in designated flood risk areas. Floodproofed construction in the flood fringe areas remains eligible for disaster assistance. Aerial photographs taken on or around the date of designation define the current extent of the existing development.

7) The Studies Agreement provides for equal cost sharing of studies on reducing flood damages to existing development. Where flood-prone developments have already taken place, studies for developing alternative flood mitigation measures must
precede construction of flood control schemes. In such cases, all practical structural and nonstructural alternatives are to be considered. Effectiveness, costs, benefits, and environmental impacts are to be accounted for when selecting among alternatives. The criterion for evaluating effectiveness of structural alternatives is a benefit-cost ratio greater than one. A "No Action" alternative of allowing flooding to continue is a reasonable option where flood mitigation is not economically feasible. Over half the funds under the Manitoba Studies Agreement ($0.3 million) have been spent to examine flood mitigation alternatives at 12 communities. The amendment to the agreement with additional funding of an equivalent amount ($0.3 million), including an extension in time, is planned to complete the program.

8) The General Agreement provides for the federal government to become involved in structural works (dams, dikes, and channel improvement) to protect existing development. The Manitoba Flood Protection Projects Agreement specifies the cost sharing of works: 45% by the federal government and 55% by the provincial government. Specific projects include the upgrading of ring dikes at eight communities along the Red River at a cost of $4.5 million and works at two other communities in southern Manitoba at an additional cost of $1.6 million. A substantial portion of works have been completed at five of the ten communities.

9) Federal cost-sharing is available for the development of flood forecasting and warning systems for rivers of "national interest," if benefits exceed costs and if the province agrees to maintain the system for a specified length of time without further federal assistance. These criteria were met in Manitoba, and a $0.6 million Canada-Manitoba Flood Forecasting Agreement was signed in 1981. This allowed the establishment of a Canada-Manitoba Flood Forecasting Centre and the development of a flow forecasting model for use on the Assiniboine, Red, and Souris Rivers in Manitoba.

Program Performance

The performance of the Canada-Manitoba FDR Program and major issues in the delivery of the program are highlighted below.

1) The mapping program is reported to have provided economic benefit in excess of costs. One study completed by Inland Waters Directorate (1986) reported a benefit-cost ratio of 5.1 for flood risk mapping, and a ratio of 1.3 if floodproofing costs are included, both at a 10% discount rate. In 13 designated communities in Manitoba, the mapping program has reduced damages to new developments in flood risk
areas by requiring floodproofing to a minimum building level, and has been able to redirect development away from most hazardous (floodway) sites.

However, the delivery of the mapping program has experienced some delays and increases in cost. This has been in large part attributable to inflation-related costs and the addition of communities to be mapped that had not been identified at the outset of the program. Manitoba was one of the first provinces to enter the program, and as experience was gained in management, the forecasting and monitoring of project costs and standards of performance have improved.

2) Studies on the FDR public information programs done in Manitoba and Ontario noted the limited influence of flood risk maps in some communities and attributed the phenomenon to the following factors (operating individually or in combination): frequent mobility of homeowners; lack of flooding-related experience; difficulty in understanding technical details such as the concept of the 1% flood; and, most importantly, the unwillingness of local governments to initiate unpopular regulations, particularly in communities with developed floodplains and/or limited access to flood-free sites for future development. A focus on a smaller target audience that could influence planners, developers, mortgage and insurance companies, banks, and real estate agents could be a more effective strategy.

3) Some communities consider public input and consultation to be an additional essential element of the public information program. The support of local governments is very important to the success of the FDR Program because most land use decisions are made locally. Productive federal assistance to provincial support of local government activities in floodplain management could be achieved by encouraging formulation of model zoning bylaws, developing video-taped demonstration projects for floodproofing, establishing mechanisms for program monitoring, regularly updating flood risk maps, and acting as a source of technical information on FDR. All FDR program-related publications are currently being catalogued in Environment Canada's computerized data bank--WATDOC.

4) Formal flood risk area designation is aimed at controlling development in the floodplain and instituting new zoning. Designation has been most successful in both respects in communities with large undeveloped floodplains and with opportunities for directing development to flood-free sites. Resistance to designation is a characteristic mainly of those communities with developed floodplains that feel the integrity of the community is adversely affected and that future community development cannot proceed after designation.
5) The potential and actual impacts of flood hazard area designation on property values has remained a controversial issue in floodplain management. Flood risk information and regulation makes buying an existing home or business or developing land in the flood hazard area less attractive. Property owners in the flood hazard area are concerned that property values will be reduced. Local governments fear that new construction and future property tax revenues will be lost.

The evidence is mixed and largely inconclusive as to whether flood hazard area designation has a direct and significant effect on property values. A wide variety of site-specific (for example, neighborhood quality, view), community-wide, and economic (for example, interest rates) variables affect the behavior of property values over time. Investigators thus have had difficulty isolating the independent, significant, and specific impact of flood hazard policies.

In Manitoba, two studies on floodplain designation's impact on residential property values support the above findings. Using time series data both before and after designation, Inland Waters Directorate (1982) did not find a consistently significant negative impact on property values in the Winnipeg area. Jarolim and Arthur (1986) recently confirmed these findings with 1984 residential sales data, comparing homes in flood-free and flood fringe areas in three neighborhoods in greater Winnipeg. Resistance to designation might be reduced if the FDR public information program were to concentrate upon informing local communities of the results of such studies.

6) Disaster assistance payments are largely subsidies to floodplain users, and, as with all subsidies, they distort market signals. The result is that a greater use of floodplains is favored. Disaster assistance payments could be used effectively to reduce future flood damages by making eligibility conditional on designation and/or by requiring that the future disaster assistance be used for relocation. This would remove the demand for repeated assistance.

7) Although the General Agreement alludes to a nonstructural policy bias, about 65% of the Manitoba FDR Program cost goes for structural measures. Remedial measures in some cases provide a better option for resolving flood problems than mapping. For instance, the decision to upgrade ring dikes at eight Red River communities was an alternative to mapping. Since there will never be enough capital funds to solve the flood problem by structural measures, strict application of the economic feasibility criterion is essential when these decisions are made.

8) Recent Red River flood survey information (Inland Waters Directorate, 1983)
demonstrates the effectiveness of the flood forecasting and warning system in Manitoba. Of the total damages that were experienced in the 1979 flood, 93.7% was attributed to structural damage with only 6.3% to content damage. A recent Canadian study (Paragon, 1985) has reported considerably higher proportions for the latter component at varying levels of flooding depth. The flood forecasting system in Manitoba is at a stage where further development efforts could be changed in favor of simpler forecasting models. An internal, unpublished evaluation report confirms the recent findings (Engman, 1986) that more complex physically-based hydrological models do not give better results than simpler ones. Engman's hypothesis suggests that model input errors can be associated with the unmeasurable spatial variability of rainfall and soil hydraulic properties.

Conclusion

The Canada-Manitoba FDR Program has resulted in a number of outstanding achievements from both the national and provincial perspectives. It has promoted consistent policies, procedures, and programs that have allowed the focusing of resources to priority areas; eliminated the need for ad hoc responses to flood events; built a logical foundation to gather and disseminate information, followed by designation and/or protection measures and then subsequent promotion of post-designation policies such as floodproofing, zoning, and flood forecasting; promoted continuing evaluation and adjustment in implementation strategies; and facilitated federal-provincial-municipal consultation. The Canada-Manitoba FDR Program provides a good example of a cooperative approach by continuous recognition of, and adjustment to provincial and local sensitivities, without sacrificing program objectives.

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Paragon Engineering Ltd.

Province of Manitoba
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Structural measures alone cannot solve all flooding problems, especially on floodplains where residents are frequently driven from their homes by floods. In such areas, flood control is a housing problem as well as a water resources problem, and planning for flood control should include consideration of housing policy. The rationale for linking flood damage mitigation policy and housing policy is clear in the light of the Federal Housing Act of 1949 that established the goal of a decent home and suitable living environment for every American family. No house fulfills that goal if it is frequently ravaged by flood waters.

To integrate housing considerations into comprehensive flood control planning in the Tug Fork River Valley of West Virginia and Kentucky, the U.S. Army Corps of Engineers undertook a major study in the late 1970s. The part of the study reported here is a housing assessment conducted in 1979. Its purpose was threefold: to define the housing situation, to identify housing and locational preferences of the valley residents, and to suggest ways to achieve national housing goals while alleviating flooding problems.

The valley of the Tug Fork River, which separates Kentucky and West Virginia, is a troublesome case for flood control planners. It is a land blessed with coal but cursed with severe and persistent flooding. The valley is one of the nation's chief producers of bituminous coal for steel making and energy production. Coal is the dominant economic base in the valley, which follows about 100 miles of the border between Kentucky and West Virginia and is the site of the historic feud between the Hatfields and the McCoys.

Since 1957, there have been four major floods in the valley culminating in a major event in April, 1977 that damaged 4,731 homes, destroying over 600 (Stanley, 1979). Flood crests in this event exceeded known records, reaching 52.3 feet at Williamson, West Virginia--more than 25 feet above flood stage. A flood wall at Williamson, designed to provide about a 78-year level of protection is now believed to provide about a 28-year level of protection based on current frequencies. (It was topped by about seven feet in the 1977 flood.) Many low-lying sites in the valley

*This study was completed when the author was a Research Associate at Cornell University, Ithaca, New York.
experience nearly annual flooding, and areas along tributaries are flooded from both headwaters and tailwaters of the river.

Such shocks to an already short housing supply are compounded by several other constraints on home building. Much of the land is owned by absentee corporate landlords interested almost exclusively in subsurface mineral and timber rights, so land is hard to acquire. The topography makes sites expensive to develop, and narrow steep roads impede the movement of building materials. Labor skilled in construction is frequently employed in the mines and unavailable for building houses. Mortgage financing is limited. Finally, federal housing regulations are often inappropriate for the area because they do not take into account the constraints of topography, land use, and financing in the valley.

So the combination of flooding, which diminishes the existing supply, and the constraints on new construction, which keep the supply from increasing, accent the need for creative solutions to the Tug Fork water resources/housing situation.

The Housing Survey

Characteristics of Homes and Households

Residents of 278 randomly-selected households in the Tug Fork floodplain were surveyed to obtain information on housing characteristics (tenure or ownership, size of housing unit, size of lot, presence of indoor bathroom, and number of persons per room) and household characteristics (income, family status, age of household head). Presence or absence of indoor plumbing was used as an indicator of housing quality.

These characteristics were related to three levels of risk in the floodplain, or "flood risk zones," identified as: 1) maximum risk, or houses in the 5-year to 20-year expected recurrence interval; 2) moderate risk, or houses in the 50-year and 100-year expected recurrence interval; and 3) minimum risk, or households located in areas where flooding is expected to occur less than once in 500 years. (These zones were established by statistically estimated frequency curves. Actual flood experience in the Tug Fork Valley includes five major floods between 1955 and 1977. The 1977 event was in the range of the 500-year recurrence interval in parts of the valley.) One hundred thirty-five houses, or 49% of the sample, were in the maximum risk category, and 78 (28%) were in the minimum risk category. (Ten units were not categorized).

Households in the maximum flood risk zone of the Tug Fork Valley were significantly different from those in the moderate and minimum risk zones in several ways.
They were more likely to be low-income households in which the household head was either elderly or a young adult. Households in the maximum risk zone were also more likely to be very small (in many cases, single elderly persons), or quite large.

Variations in housing characteristics by flood risk zone were evident, but none were statistically significant. There was a higher proportion of rental housing in the maximum risk zone and a greater density of housing units. Less clear was the relationship between flood risk zone and such variables as bathroom facilities, crowding, and size of unit, although there was some indication in the data that units in the maximum risk zone were more crowded and smaller than homes in the other zones. 

Willingness to Move

It has generally been thought that residents of floodplains do not desire to move. However, little research has been done to confirm or deny this thesis—especially in situations where low income and other constraints influence the decision to move. According to Kates (1962) mobility—in this case, relocation away from the floodplain—can be expected as a mode of adjustment to avoid natural disaster. Mobility is also more likely to occur if families are dissatisfied with their housing because it fails to meet their needs for space, status, or other amenities. Actual mobility of Tug Fork households has been somewhat limited: 19.4% of the households have lived in their home for 1 year; 23.7%, 2 to 5 years; 12.9%, 6 to 10 years; and 43.9%, more than 10 years.

The 278 survey households in the Tug Fork River Valley were asked the question: "If decent, affordable housing were available to you outside the floodplain, would you be willing to move?" More than 66% of the respondents answered affirmatively. Of those willing to move, 41.5% did not want to move any further than out of their immediate neighborhood; others were willing to relocate elsewhere in the valley, and even out of their county or beyond. These positive attitudes toward moving might appear contradictory in the light of past behavior of Tug Fork residents, since mobility rates have been low. But actual moving behavior (as opposed to attitudes toward moving) can be influenced by numerous constraints such as personal income, availability of housing and housing sites, and availability of mortgage money. These constraints, particularly evident in Tug Fork, have held mobility to a minimum.

Characteristics of Potential Movers

Previous research has found that people expressing a willingness to move are likely to be members of either young, single-person households or households experiencing crowding, or are renters (Rossi, 1955; Morris and Winter, 1978). Data from
the Tug Fork survey were analyzed on the basis of these factors, as well as on the basis of location in the floodplain. The analysis indicated a significant difference by age in the willingness to move. Young households--those with a household head under 35--were much more likely to be willing to move than households with older heads. The oldest households--those with a household head over 65 years of age--were least likely to want to move. This is consistent with established mobility theory: older households are unlikely to want to move unless they experience a family disruption such as retirement or death of a spouse (Rossi, 1955; Morris and Winter, 1978).

Data on the relationship between crowding and willingness to move confirmed the hypothesis that crowding predicts high mobility rates. Households with more than one person per room were much more likely to be willing to move than were those with fewer than one person per room. Renters in Tug Fork were also more likely to be willing to move than owners. Family groups most likely to be willing to move were husband-wife families with children and extended family groups (families that included other relatives in addition to parents and children). Although the differences were not statistically significant, some interesting variations in willingness to move emerged relative to position in the floodplain. Residents of the 5-year frequency floodplain, as might be expected, had a high rate of positive response (72.7%) while residents in the Standard Project Flood (SPF) and minimum damage zones showed relatively lower rates of positive response (55.6% and 59.6%, respectively). The relationship between flood experience and willingness to move was not linear, however. Residents of the 50-year frequency floodplain had a relatively low positive response to moving (42.3%), while residents of the 500-year frequency floodplain were more likely to be willing to move (70.6%).

It appears that, at least in the case of Tug Fork, flood experience alone cannot be used as a predictor of potential moving behavior. Other factors, such as family structure, age, and quality of life must be considered as well. In Tug Fork, certain types of households were likely to be more willing to move than others. Young households, in which the head is 35 years of age or younger, and which include husband, wife, and children, appeared most receptive to voluntary relocation. Extended family groups, single-parent households, and renters of all ages were also likely to be amenable to moving. It is these groups to whom new housing opportunities would most likely be appealing, and to whom a voluntary relocation program might be directed most successfully.
Satisfaction with Current Housing

As part of the Tug Fork survey, respondents were asked questions pertaining to their satisfaction with the housing they currently occupy, the location to which they would be willing to move, and the kind of housing they would most like to have in the future. Respondents were also categorized by stage in the family life cycle, socioeconomic status, and exposure to flood risk, so that groups most willing to take advantage of new housing opportunities could be identified.

Location of the house was an important factor in both housing satisfaction and housing dissatisfaction. Residents liked the fact that their housing was conveniently located, close to work, school, church, and other activities. At the same time, they disliked the fact that they were located in the floodplain. Tug Fork residents also displayed close neighbor and family bonds, which enabled them to have a high level of housing satisfaction even though many structures appeared to be of poor quality.

The identification of strong neighborhood bonds and sentimental attachment to homes provides important information to planners. Despite a strong willingness to move, satisfaction with voluntary relocation is likely to be strongly linked to neighborhood as well as housing factors. Since neighborhood ties are so strong, even those residents willing to separate from the old neighborhood are likely to seek opportunities to resume strong neighboring patterns in the new neighborhood. Successful comprehensive planning for new housing options, as in the case of Tug Fork, probably should consider not only the provision of physical structures, but also provision of an environment conducive to the formation of new neighboring patterns and the maintenance of old ones.

Preferences for Future Housing

The second step in the housing preferences analysis was to determine what Tug Fork residents might look for if they chose a new housing location. Pictures of five different kinds of housing were shown to the respondents, who were asked to give their first and second choices. Housing types were selected because they either represented the kind of housing presently existing in the valley or housing that had been proposed for future development. Selections were: a garden apartment; a rustic, mountainside house; a mobile home; a small, single-family home; and a contemporary high-rise apartment building.

As might be expected, the overwhelming choice of Tug Fork residents was the single-family home--the housing option selected by half the respondents was a small,
one-story home, typical of those found in the Tug Fork area. However, nearly one-fourth (23%) of the respondents selected another type of single-family home that was not as familiar—a rustic, A-frame "mountain house" that might be offered in future housing options because it is less expensive and better adapted to rugged terrain than traditional houses.

The mobile home, so much in evidence in the Tug Fork area, ranked a poor third in terms of preference (9%). This supports the conventional notion that mobile homes are found in abundance more as a result of necessity than of desire. High-rise and garden apartments were almost totally unacceptable as a first choice of housing (3% and 5% respectively).

The second choice of respondents indicated the kind of housing residents might find acceptable if their first choice were not feasible. The desire for single-family housing still predominated, but the proportions changed so that there was almost equal preference for the conventional single-family home, the mountain home, and the mobile home. However, nearly half the respondents in the sample would not give a second choice of housing. Their first choice—in most cases the conventional, single-family home—was the only choice they would make.

Conclusion

In areas such as the Tug Fork River Valley, a combination of approaches to flood mitigation appears to be necessary. Economic, topographic, and other constraints make protection of some parts of the valley impossible; the only solution is to help families relocate from strip developments along the floodplain to economical and attainable sites out of the floodplain. Further development can then be restricted to nonresidential uses, such as recreation, that are less sensitive to flooding. Data from the Tug Fork survey support the concept that comprehensive water resources planning can link housing solutions with flood control measures. In this case, at least, floodplain residents are willing to relocate if acceptable housing options can be provided. The study provides information on what groups or households are most willing to move, where they are willing to move, and what type of housing would be most desirable to them. The big "IF", of course, is whether acceptable housing options can be provided. The study did not assess how much floodplain residents would be willing and able to pay for alternative housing, or how much the whole community would be willing to pay to develop and maintain the floodplain after relocation. These questions lead inevitably to policy questions—regarding cost
sharing for relocation, floodplain management, and housing assistance programs—that must be answered before the approach can be implemented.

The benefits of the joint water resources/housing approach go far beyond the reduction of flood damages to property. Residents of high-risk areas have the opportunity to improve their quality of life by avoiding the trauma of constant flooding as well as improving their housing and neighborhood environment. Communities may also acquire benefits in the form of reduced disaster assistance costs and the potential for improved community cohesion and stability. National benefits accrue from maintenance and improvement of quality of life in an area that contributes substantially to the U.S. supply of natural resources. From a humanitarian perspective as well, it seems reasonable to attempt to provide housing that does not pose a constant threat of physical injury to its occupants. For this persistent threat, as previous experience has shown, can have long-lasting effects on both emotional and physical well-being. Finally, achievement of an objective of decent, safe, and sanitary housing for all residents is consistent with federal legislation that has been in existence for more than 30 years.

References
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SELF-HELP FLOOD MITIGATION: ORGANIZING THE COMMUNITY THROUGH PLANNING

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Introduction

There are 45,000 miles of streams and rivers in Pennsylvania which pose a threat to people and property during times of heavy or prolonged rainfall or early spring runoff. Such was the case in 1972 as the heavy rains of tropical storm Agnes battered Pennsylvania and much of the Middle Atlantic region of the United States. When the waters receded, all of Pennsylvania's 67 counties were declared disaster areas, over 50,000 people were out of work, and $3 billion worth of property was either damaged or destroyed.

Lycoming County was one of those areas particularly hard hit by Agnes. It contains nearly 2,200 miles of streams, and 98% of it lies within the drainage area of the west branch of the Susquehanna River, the county's most dominant waterway. The west branch flows for 38 miles from the western to the southern borders of the county, and the majority of the county's population is located along or near the river. There are six major tributaries to the river in the county.

Flooding is an almost annual event along many of these waterways. In 1972, flooding caused by Agnes lasted from 3:00 p.m. on June 22nd until 7:00 p.m. on June 27th. At times during those five days the water level of the west branch of the Susquehanna River rose at a rate of more than one foot an hour. It ultimately crested at 35.75 feet at Williamsport, 32 feet higher than normal for June and almost 16 feet higher than flood stage. At Muncy the water level reached 37.45 feet, 14.5 feet above flood stage. Over 34,000 acres of Lycoming County were under water, 13,000 buildings suffered some kind of damage, 2,800 homes were either damaged or destroyed—including 350 mobile homes of which 150 were completely destroyed. Total damage in the county amounted to $54 million.

Although tropical storm Eloise in 1975 did not penetrate as far inland as Agnes, flood levels along many streams in the eastern portion of Lycoming County were within a few feet of the levels reported in 1972, and reported damage totalled $9 million. Following this event, many people in the county began to see the need for an effective floodplain management program which would stimulate the public's awareness of flood hazards and begin to reduce or minimize future flood losses. What resulted after years of diligent effort is the county's present integrated system of floodplain management which has three major components: 1) an ongoing program of con-
scientious floodplain land use management, 2) a well-organized flood early warning system, and 3) an aggressive program of public and private emergency flood preparedness and evacuation planning. Working together, these elements make up a highly successful, reliable floodplain management program.

In Lycoming County, floodplain management involves a full range of carefully planned public policies and actions designed to promote wise use of the floodplains and reduce future flood damages. Being comprehensive, this floodplain management program includes both corrective measures to rectify existing problems and preventive measures to keep new problems from developing in the future. This paper provides a brief overview of some of the existing elements of the county's floodplain management program and of measures that are being planned for the future.

Floodplain Land Use Management

Following the Agnes flood in 1972, the county planning commission staff began a concerted effort to encourage each of the county's 52 municipalities to adopt appropriate land use and building regulations to ensure participation by those communities in the National Flood Insurance Program. It was our aim to ensure that federally subsidized flood insurance was available at reasonable rates to the citizens of the county. That initial effort met with some success, but it was not until tropical storm Eloise struck the county in 1975 that the remaining municipal officials began to realize that controls regulating new land uses in the floodplain were necessary if future flood damage was to be reduced. By 1977, all but five municipalities in the county were participating in the National Flood Insurance Program. Specific flood insurance mapping had been prepared by the Federal Flood Insurance Administration for each of the 47 participating communities, and in return, each of the municipalities had adopted floodplain land use regulations aimed at limiting future development in flood-prone areas.

To further reduce flood damages statewide, the Pennsylvania legislature adopted a State Floodplain Management Act in October of 1978 (Act 166 of 1978) which was primarily designed to encourage those flood-prone municipalities not already participating in the National Flood Insurance Program to do so. As a result, the five remaining nonparticipating Lycoming County communities each were convinced of the benefits of sound floodplain management, and each executed the necessary paper work to join the National Flood Insurance Program. Thus, after ten years of effort, land use regulations now exist throughout Lycoming County which limit the type and extent
of new development permitted in the floodplain and which require floodproofing for those activities that are approved.

Two other techniques aimed at controlling future floodplain property usage were also utilized to reduce flood damages in the county: land acquisition and relocation. Following the devastating floods in 1972 and 1975, the county was able to take advantage of state and federal disaster relief funds to acquire and clear numerous heavily damaged and highly susceptible properties. Some of the properties were then sold back to private individuals for more appropriate floodproofed development, and others were donated to communities for public recreational uses. Still other residential sites were purchased (on a voluntary basis), their buildings demolished, and the inhabitants relocated to homes outside of the floodplain in an effort to eliminate repetitive flood insurance claims. Disruptions of municipal populations and tax bases were kept minimal by relocating families in the same communities.

In addition to other assistance provided, the staff of the county planning commission has also joined with personnel from numerous other regional, state, and federal agencies to form an industrial flood preparedness team to address the unique concerns of industry located in the floodplain. When requested, this team evaluates existing industrial operations affected by flooding and, following their assessment, makes recommendations regarding preparedness efforts, emergency actions, and floodproofing techniques that might be instituted to minimize flood damages and reduce "down time" during future flooding events. Since its inception in the late 1970s, this team has evaluated several flood-prone industries in the Susquehanna River basin and has been responsible for the initiation of thousands of dollars worth of floodproofing efforts that have already saved tax payers countless dollars in post-flood damage assistance.

**Flood Warning System**

Local interest in the development of an accurate, efficient early flood warning system dates back to June, 1972 and the Agnes flood. Information available on flood heights for Lycoming County watersheds during the 1972 flood was very inadequate and, for the most part, rather unreliable. River gauges were damaged during flooding, radar coverage was incomplete, and precipitation data was insufficient. Coupled with the lack of formal flood warning procedures, considerable confusion existed. As a result, county and municipal officials did not have dependable data upon which to base flood crest predictions or forecasts, nor were they able to make well-determined
decisions to begin evacuation or other responses.

By 1976 however, after the county had suffered its second major flood in three and a half years, it became evident that something had to be done to minimize damages to existing development located in the floodplain. A self-help volunteer flood early warning system resulted. Over 100 citizens were recruited and trained as volunteers and stream and rain gauge observers, and, with the help of the National Weather Service, forecasting procedures were established for each county watershed. Within three months after its inception and for an initial investment of $500, a flood warning system was put into operation.

Volunteer observers monitor rain and stream gauges and report their findings to their stream coordinator. Stream coordinators assemble the data from their watersheds and in turn convey it to the system coordinator. He or she, with the help of numerous other staff and expert personnel, evaluates the information and determines what degree of flooding should be expected and what emergency response actions should be taken.

Although relatively simple, the system has proven quite effective since its inception in 1976. During one flood in early March of 1979 for example, the system was credited with reducing flood damages in Lycoming County by $750,000. Residents, businesses, and industrial concerns were provided with adequate early warning so that they could evacuate and relocate equipment and inventory which undoubtedly would have been damaged if not moved. Predicted flood levels turned out to be within one foot of actual levels in most areas of the county.

The overall effectiveness of the system has been enhanced over the past ten years with a number of built-in backups. Because of possible unexpected weather conditions (including thunderstorms of varying intensity), the risk of error in run-off and stream flow calculations, and the vulnerability of data in both collection and transmittal, it was not desirable to depend heavily on any one single aspect of the system. Thus, a series of backup personnel, communication devices, and additional data collection methods were included in the system to provide the most accurate information possible upon which to base flood predictions.

NOAA weather radios were provided by the county to all of the volunteer observers and base station radios were distributed by the National Weather Service to each stream coordinator in order to assure adequate communication backup should traditional telephone linkages become inoperable. Further, the manual data collection system was enhanced by the addition of the National Weather Service's IFLOWS system: a
system of ten automated rain gauges and four automated stream alarm devices strategically located throughout the county's watersheds. The information received from these devices is reported to a computer located in the county communications center; it, in turn, is used to predict flood heights and locations.

**Municipal Flood Stage Mapping, Flood Preparedness, and Evacuation Planning**

Using the detailed hydrologic data contained in the municipal flood insurance studies, stream flow history, and documentation from various USGS gauging stations located throughout the county, the Baltimore District of the U.S. Army Corps of Engineers was able to compile detailed flood stage forecast maps for the most densely populated and heavily developed areas of the county, including those municipalities situated adjacent to the Susquehanna River. These maps illustrate staged inundation areas based on water levels experienced at various upstream gauges. The information provided by the flood stage maps—when combined with existing prediction procedures and forecast knowledge, measurements provided by the system volunteers, and technical documentation made available by the IFLOWS system—has substantially enhanced site-specific prediction and warning capabilities throughout the county.

Combining these improved prediction capabilities with a thorough flood preparedness and evacuation planning effort for each affected municipality served to further highlight the value of the new mapping by reducing damage and losses caused by flooding. The county planning commission has recently met with many municipalities and established flood evacuation procedures for communities for which flood stage forecast maps were prepared. Local government officials, Red Cross personnel, municipal emergency management coordinators, as well as representatives from appropriate police and fire departments were all involved in public preparedness planning sessions during which individualized evacuation responsibilities were discussed and assigned. Once specific procedures were established, sessions were held with residents and property owners in each of the areas to make them aware of their role in the community's evacuation efforts and to encourage them to consider their own personal evacuation needs before actual flooding occurred. Although it has not yet been completely tested, all indications are that this preparedness planning should reduce total flood insurance claims and replacement costs even further.
Summary

The primary objective of the county's floodplain management, flood warning, and emergency preparedness efforts is to provide early notification of impending floods so that prompt action can be taken to safeguard lives and reduce property damages. Such planning should also increase safety, reduce other damage, and insure the provision of vital goods and services for the populace during floods.

Because of the relative ease of adaptability, the comparative low operating cost, and successful results, the authors encourage the implementation of self-help flood mitigation systems, perhaps even on a national or international scale. For any jurisdiction adopting such a system, each region affected by riverine flooding should be evaluated; a rigid program of floodplain land use management instituted; a volunteer early warning system developed (with the addition of automated devices where appropriate); and flood stage forecast maps prepared to enhance prediction capabilities. Community awareness and education programs should also be established to emphasize the benefits of preparedness planning and evacuation efforts. If more areas of the country apply these or similar flood hazard mitigation techniques, a significant savings would undoubtedly result for both government and individual citizens.
IMPROVING FLOOD HAZARD MITIGATION PROGRAMS: A LOCAL PERSPECTIVE

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Introduction
This paper summarizes what has recently been accomplished in flood hazard mitigation in the Village of Kampsville, Illinois, a small town (population 423) located 30 miles above the confluence of the Illinois and Mississippi rivers on the narrow peninsula between these parallel-flowing streams. Aided by a part-time local coordinator, the village prepared a hazard mitigation plan (1985) and secured federal and state funding to carry out the plan. Based upon that experience, this paper presents a six-step procedure for accomplishing floodplain management goals on the local level, and concludes with a discussion of some deficiencies of federal and state flood damage reduction programs as perceived from the local level.

The Kampsville Mitigation Project
Kampsville was built on the banks of the Illinois River in 1878. Although, there had not been a large flood in the area since 1844, a major flood occurred in 1922, following construction of agricultural levees along the Illinois River, and another occurred in 1943. There were no further serious floods for 30 years, until the record flood of 1973 caused by coincident high water on the Illinois and Mississippi Rivers. Kampsville has experienced seven floods since 1973 and was declared a state and federal disaster area four times in six years.

Kampsville has 111 buildings--nearly half of the town's buildings--in the 100-year floodplain. During a flood, all state highways to Kampsville are under water, the ferry is closed, and access is limited to poor gravel roads through the hills (which were themselves closed to truck traffic during the 1985 flood). Most major businesses are subject to flooding, including both restaurants and the grocery store. During most floods, the water rises and falls slowly, generally flooding the town for several weeks. Tax revenues for the village and employment opportunities have declined due to the interruption caused by the flood season and the permanent closing of flood-prone businesses. As the frequency of flooding has increased in Kampsville, many of the elderly have become unable to cope with the paperwork involved in applying for flood insurance claims and disaster assistance after each flood. Some people have just given up and dropped their flood insurance. Others have elevated their homes or businesses, but generally not high enough to be adequately protected.

After the December, 1982 and April, 1983 floods, FEMA decided to consider
Kampsville for a Section 1362 buy-out project. Only people who signed up at the
disaster center were included in the buy-out plan, and no one from the village was
involved in coordinating the project. FEMA decided not to fund the Kampsville buy­
out that year.

At that time, the mayor appointed me to fill a vacancy on the village Board of
Trustees and also to take the position of ESDA coordinator. I am a botanist employed
by the Center for American Archeology and was inexperienced in local government. I
was well acquainted with effects of flooding, however, since my own home had been
inundated several times, and I was determined to coordinate the efforts to seek help
for Kampsville. I began by arranging for a FEMA representative to come to town in
December, 1983 to suggest what Kampsville could do to be reconsidered for a buy-out.
The meeting was very helpful; FEMA said that if the village had an economic develop­
ment plan, a reuse plan for the land to be bought out, and new data sheets for each
house in the buy-out, the application could be resubmitted to Washington in two
weeks. I completed the necessary paperwork in one week and sent it to the regional
FEMA office. Information was submitted on everyone who was potentially eligible, not
just those who had signed up at the disaster center. One year later the application
was completed by the Chicago office and forwarded to Washington. Over three years
have passed since the initiation of the buy-out process in April, 1983; at the time
this paper was written, FEMA had not yet made offers to property owners, but the
agency is scheduled to do so in late July, 1986.

Meanwhile, Kampsville has received other assistance from FEMA and the Illinois
Department of Transportation, Division of Water Resources (IDOT-DWR) to prepare for
the buy-out of 29 buildings with FEMA funds. French Wetmore of IDOT-DWR provided
advice and technical assistance in surveying first floor elevations of buildings and
assessing building conditions, and he suggested that Kampsville apply to FEMA for a
mitigation planning grant. This enabled the village to set up a floodplain planning
committee and to write a hazard mitigation plan which also served as an economic
development plan. Specifically, the grant enabled me to take time off from my
regular job to write plans and prepare grant applications for the village in order to
bring together funding from several sources. I wrote a successful proposal for
Illinois Community Development Assistance Program funds to elevate homes that had
been flooded but were not in the buy-out. Wetmore worked through IDOT-DWR to have
state funds allocated to Kampsville and other towns for acquisition and clearance of
additional floodplain land and for floodproofing public facilities such as the water
Asch plant. So far, over $1 million has been committed to buy out or elevate buildings and to create a riverfront park. The Illinois Department of Transportation is committing an additional $517,000 to reconstruct and elevate the ferry landing, so Kampsville will not be isolated during floods.

**Recommendations to Small Towns**

Based on experiences with the Kampsville Project, it seems that there are certain steps which could be followed by any of the 20,000 flood-prone communities in the U.S. in order to achieve floodplain management goals. An ideal program for floodplain management on the local level involves at least six steps.

1) **Designate a local coordinator.** State and federal administrators of floodplain programs should request that a local government select a local coordinator who can be an advocate for floodplain management and act as a go between for the citizens and the federal or state agency. Without local involvement, people or projects that need help may be overlooked. The coordinator should be a local person trusted by the community, who can communicate, understand rules and regulations, do paperwork, and understand grantsmanship. When selecting a contact person, the federal or state agency should be aware of the possible conflicts of interest that can arise in a small town, where a few people seem to do most of the work.

2) **Obtain administrative funds or a planning grant.** Most small rural towns do not have funds available for floodplain management. Using Kampsville as an example, the village has only one full-time employee and lacks even sufficient funds to buy a lawn mower to maintain the riverfront park being created with federal and state funds. This spring the village held two bake sales to buy a new lawnmower. Floodplain management work in Kampsville began on a volunteer basis, but because it was very time consuming, it became necessary to seek funding to allow me to take time off from my regular employment. Perhaps some towns could work successfully with regional planning commissions, but many commissions now charge a fee to write proposals, and a local coordinator is still needed to work with the commission. Federal and state agencies should work to make more planning grants and technical assistance available to local governments.

3) **Appoint a floodplain planning committee.** In Kampsville, the mayor appointed a committee whose main objective was to plan effective responses to the flooding hazard. The committee consisted of seven Kampsville residents and technical advisors from federal, state, and county agencies. After its plan was produced and adopted by
the village board, the committee became inactive because the ultimate authority for carrying out the plan rested with the board. Ideally, the planning committee should continue to function as an advisory committee for the local government.

4) **Assess needs by surveying building conditions, first floor elevations, and property owners' needs and preferences.** In a small town, the planning committee can conduct these surveys, or, alternatively, they can be carried out by a staff person. For Kampsville, the Illinois Division of Water Resources assisted by aiding in the survey of first floor elevations. The results of the surveys can be used as documentation in applying for assistance from federal and state agencies. A survey of first floor elevations is also essential for creating an effective flood warning and response plan.

5) **Identify goals for floodplain management in conjunction with economic development.** The Kampsville Floodplain Planning Committee discussed floodplain management objectives within a wider context of village needs, responsibilities, and resources, and eventually defined six goals for flood hazard mitigation. These included a) redeveloping the floodplain to be a village asset, b) maintaining a centralized business district c) eliminating flood damages to buildings, d) maintaining state road access during high water, e) maintaining key public utilities, and f) providing affordable housing for relocated floodplain residents. Then, based upon the goals, the data gathered on building conditions, property owners' interests, and a knowledge of the sources of financial assistance, the committee recommended six projects that should be carried out with a timetable for each.

6) **Seek local, state, and federal funding to accomplish the goals.** In the Kampsville project, it was found that once funding was secured from one agency, those funds could then be used as leverage when applying for funds elsewhere. Needless to say, it may take several years to secure the funds to complete a project. However, without goals and a written mitigation plan, it is unlikely that a community's flooding situation could ever improve. With a plan, it is likely that after another major disaster, parts of the plan can be implemented with help from federal and state agencies.

**Recommendations to State and Federal Officials**

As seen from the local level, a number of floodplain management problems are presently not being adequately addressed by federal and state programs. Five suggestions for improved service are offered here.
1) **Speed up the acquisition process.** Immediately after a disaster, people are anxious and ready to move out of a floodplain. Federal and state disaster relief programs should be designed to take advantage of this willingness to relocate. The FEMA 1362 program proceeds much too slowly and is unreasonable in some of its expectations. For instance, the March, 1985 flood crest occurred eight days after the buy-out was approved, and Kampssville property owners were informed that insurance settlements would be deducted from the buy-out offer and that they would not be reimbursed for any repairs. Of the town's two restaurants, one made repairs and soon reopened. The other one did not, and instead waited for the buy-out to proceed. When (after 17 months) the buy-out offers are finally made, that restaurant will be essentially bankrupt because of the loss of business, and the other restaurant will have ended up with all the regular customers. In addition, several homes have become vacant and unkempt because discouraged homeowners moved out before the buy-out offers were made.

2) **Fund nonstructural flood control.** According to Burby (1985), about 70% of the flood-prone communities in the U.S. have structural flood control devices in place, whereas only 2 to 3% of the flood-prone communities have relocated buildings from flood hazard areas. Historically, this must have related in part to the relative availability of state and federal funds for structural versus nonstructural flood control measures. Most local floodplain residents that I know would welcome the opportunity to move their homes and businesses out of the Illinois River floodplain in which the annual expected high water has increased by about four feet during the past 45 years (Village of Kampssville, 1985). But federal programs for acquisition, such as the FEMA 1362 program, have relatively rigid guidelines as to how funds can be expended, and local funds are generally not available for acquisition. State funds, when available, can be more flexible and can be used to fill the gaps between federal and local funding. For example, in Kampsville, state community development funds are being used to elevate homes and relocate families. Elevation of homes was an attractive alternative to moving out of the floodplain entirely, because of a large investment in the existing floodplain water and sewer systems and because of the lack of space for expansion between the river and the confining bluffs.

Illinois is fortunate in having a forward-looking Division of Water Resources that is setting aside capital development funds for nonstructural flood control measures. Kampssville will use IDOT-DWR funds to accomplish tasks not covered by other programs, such as demolition of buildings, acquisition of property not eligible
for 1362 funds, and floodproofing of the water plant.

3) **Help the helpless.** In many communities, people living in flood-prone housing typically are among the poorest citizens and least likely to have the knowledge and financial resources to solve their problems. Yet funding is targeted in such a way that it helps those that are most able to help themselves. Both the FEMA and IDOT-DWR programs are set up to give priority to those communities that are organized to seek assistance for solving flood problems; this can discriminate against small communities without leadership that are inexperienced in working with other government agencies. Within communities, people who cannot effectively represent their own interests may also lose out. Federal and state programs should be reviewed from the point of view of identifying and assisting such individuals.

4) **Help isolated property owners.** Many floodplain property owners do not live in areas with a strong local government. Each time my name appears in the local newspapers because of the Kampsville Floodplain Project, people call from throughout the county and from adjoining counties asking how their property can be bought out and how they can relocate out of the floodplain. I refer them to the FEMA regional office and offer assistance if they need help with the paperwork. However, the FEMA 1362 program is now designed to give highest priority to acquiring contiguous property in areas with a well-developed reuse plan. If a flooded house is in an isolated area, the owner can submit a request to be bought out, but it is unlikely that the buy-out will occur.

5) **Put people before parks.** From a local perspective, there is a problem of balancing the importance of getting people out of the floodplain versus the desirability of creating a public use for the acquired land. Presently, great weight is given by federal and state agencies to planning for a significant future public use of the acquired land. In Kampsville, it would never have occurred to the community to undertake expansion of the existing riverfront park. The plan was drawn up primarily because it seemed a fundable idea that would interest other government agencies and also give people an opportunity to move out of the floodplain. Property outside of the proposed park area has a lower priority for acquisition. Most floodplain residents feel that it is much more important for agencies to buy up flood-prone property, wherever it may be, than to try to realize a concept such as a developed park facility.

For land lacking a sound potential public use, program guidelines should be more flexible, permitting groups or individuals besides local governments to hold the
land. For instance, for isolated properties, the Peoria County Hazard Mitigation Plan (1985) recommended that federal and state agencies consider deeding acquired property to an adjacent property owner if he a) floodproofs his own property, b) agrees to incur the cost of demolition, and c) agrees to keep the acquired property as open space. Private ownership shifts the responsibility for upkeep from the public sector and would even yield a small return in property taxes. To qualify for flood insurance, Kampsville enacted a strict floodplain zoning ordinance that prohibits rebuilding on such properties below the 100-year flood elevation. Thus, private reacquisition of floodplain land should not result in future flood insurance claims or require continuing disaster assistance.

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Peoria County, Illinois  

Village of Kampsville, Illinois  
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Introduction

This paper describes the development of a comprehensive flood control master plan recently completed for Clark County, Nevada. It emphasizes the planning and administrative aspects of the project which involved the development of a flood control program for a rapidly growing area of the Southwest.

Clark County is located in southernmost Nevada. It encompasses a major urban center in the Las Vegas Valley (the cities of Las Vegas, North Las Vegas, and Henderson), other growing urban areas (Boulder City, Mesquite, and Laughlin), and many small communities in outlying areas. Clark County's is a desert environment, with severe flood events typically produced by local, intense summer thunderstorms. Much existing and future development is located either on alluvial fans or adjacent to highly erodible washes.

In the past two decades Clark County has experienced significant growth. Although several major flood control improvements were constructed during that time, no overall plan for flood control existed, and no agency was in place to establish regional flood control criteria. This project involved the preparation of the first county-wide flood control master plan, identifying improvements to provide 100-year protection. Equally important, the plan set forth procedures for establishing a new Clark County Regional Flood Control District (CCRFCD) to administer the program.

Summary of Engineering Study

Several important aspects of the engineering analysis performed for development of the flood control master plan are discussed below.

Precipitation Analysis

Clark County has little historical rainfall data. There are only three recording rain gauges in the county, and the localized nature of thunderstorms makes measurement by this sparse network very inaccurate. As a result, previous flood studies have been based on data from the NOAA Precipitation-Frequency Atlas for Nevada. However, an analysis of the data for the three gauges was recently performed, and it was found that for short duration thunderstorms (3 hours or less) the
NOAA atlas underestimates storm depths by about 44% at the 100-year level. Therefore, the master plan facilities were sized based on NOAA storm depths adjusted by a factor of 1.44.

It has been found that discrepancies between the NOAA atlas and actual local data are common in the West. In Clark County this means that existing facilities designed using NOAA data may be substantially undersized, providing a lower level of protection than originally envisioned. This study found that flood control planners clearly should rely on local information as much as possible and avoid using the NOAA atlas. At the same time, it suggests that planners should develop expanded gauging programs while encouraging NOAA to update its atlas.

Watershed Modeling
In order to facilitate formulation and evaluation of flood control alternatives, a rainfall/runoff simulation model was prepared for every major watershed in the Clark County study area. Selection of an appropriate model was based on: 1) accuracy in modeling urban as well as undeveloped areas; 2) determination of parameters from readily available information; 3) quality of program documentation. Most previous studies in the area had been conducted using the SCS TR-20 program or TR-55 manual.

It was decided to use the HEC-1 Flood Hydrograph Package, with the SCS unit hydrograph method applied to sub-basins with little or no development and the kinematic wave method applied to sub-basins of predominantly urban land use. This allowed the greatest flexibility in modeling different land uses. HEC-1 has parameters which are fairly easily derived, and the documentation from the Hydrologic Engineering Center is excellent. Use of the SCS method for undeveloped watersheds allowed TR-20 models prepared for a recent flood insurance study to be easily adapted into the master plan analysis for several major study areas. Over 2,500 square miles of watershed were modeled with HEC-1 to determine 100-year design flows and evaluate various flood control alternatives.

Flood Control Alternatives
Two primary alternatives were developed for each study area. "Conveyance alternatives" utilized a system of channels, conduits, floodways, and new bridges to convey full flood flows safely through developed areas. "Detention/conveyance alternatives" used detention or retention basins to reduce flows to levels within or close to the capacity of existing conveyance systems.

To facilitate evaluation of the many flood control projects proposed for the
study area (over 1700 structures in the recommended plan alone), it was necessary to define every "project" as a combination of 13 basic elements: box conduit, pipe, open channel, floodway, channel lining, drop structure, detention basin, spillway, outlet structure, dike, bridge, or right-of-way acquisition. A database was developed that included structure identification, type, size, and/or quantity. A cost estimating program was then written using unit cost curves from local construction projects, which could be applied to the structure descriptions to derive a project cost estimate. This program proved invaluable in efficiently computing and summarizing the many cost estimates for all alternatives, and was a key product of the project.

Alternatives in each study area were evaluated on the basis of reliability, flexibility, and affordability. In nearly every area the detention/conveyance alternative became the recommended flood control solution. The full cost for providing 100-year protection to Clark County with the all conveyance alternative was estimated to be $1.38 billion; with the detention/conveyance alternative the cost was reduced to $835 million—clearly demonstrating the economic advantage of detention basins in urban flood control.

In addition to structural projects, the master plan focused on nonstructural floodplain management methods. Among the most important of these were "incentive zoning" (i.e. allowing higher development densities in areas outside floodways in exchange for leaving floodways undeveloped), development of an advance flood warning system, and community preparedness programs.

**Summary of Implementation Program**

An important part of the formation of the master plan involved setting forth the administrative framework for the new flood control district and assuring that it would ultimately be approved by Clark County voters in a general public election. Important aspects of the resulting implementation program are discussed below.

**Local Development**

Urban areas of Clark County are currently being intensely developed, and there is strong pressure to continue this growth. Local development interests have extensive political power, and in the past it has been difficult to regulate land use in floodplains and to guarantee construction of adequate flood control facilities for new developments. Adoption of the master plan will include implementation of a new floodplain management ordinance which, at a minimum, will require developers to:
1) dedicate the land necessary for flood control improvements identified in the master plan, 2) do the excavation necessary to carry anticipated flood waters, and 3) make necessary interim improvements to protect the developed property.

In order to standardize local design practices, a "Flood Control Design Policy Manual" was produced which outlines the criteria to be used in designing drainage facilities in the master plan area. These guidelines should ensure that local drainage facilities are sized consistently with the regional flood control facilities and that there is a fair and uniform apportionment of the cost of extending the present drainage and flood control system to newly developed areas. Thus, enforcement of the procedures in the "Design Policy Manual" is critical to the effective implementation of the master plan program.

Politcal Conflicts

The Clark County study area comprises five incorporated cities, three major areas of development in unincorporated territory, and 12 small unincorporated communities. These entities all have different objectives concerning growth, development, and flood control planning; and, not surprisingly, these objectives clashed frequently during preparation of the master plan. Part of the problem arose because the three cities in Las Vegas Valley had recently commissioned their own flood control master plans and were concerned that the county-wide study might invalidate their own planning. This concern was mitigated by incorporating as much of the local plans into the regional plan as possible, and by working to assure that the regional plan would be consistent with local objectives.

A critical part of developing the master plan study was understanding the political priorities and objectives of each entity, including their perceptions of acceptable engineering solutions and of appropriate functions for the CCRFCD. To accomplish this, interviews were conducted with all key public officials and results were distributed for review. An implementation program was developed to meet as many of the objectives of the entities as possible, although, in many cases, conflicting priorities could not be reconciled. These differing local perspectives, although making the planning process more difficult, underscored the need for a "regional" flood control district that could provide a county-wide approach to storm water planning.

District Administration and Priorities

The concerns of local agencies focused primarily on the need to mitigate the effects of flooding in critical areas by constructing several key projects as quickly
as possible. Thus there appeared to be a local emphasis on projects rather than programs. However, the high cost of the master plan facilities ($389 million for phase one facilities to protect existing areas) will preclude implementing large portions of the plan for many years. Therefore, there must be immediate attention to program elements (e.g., hazard reduction programs, flood alert systems) to prevent excessive damage before the master plan projects can be completed. As a result, it seems likely that there will be conflicts over funding priorities; high profile projects which visually demonstrate that CCRFCD is producing "results" will compete with programs that reduce flood impacts but do not involve physical structures. The early success of the CCRFCD may hinge on its ability to maintain a balance between these two competing needs.

In considering possible CCRFCD organizational functions, the experiences of established flood control agencies in the West were reviewed (Maricopa County, Arizona; Pima County, Arizona; Denver, Colorado; Albuquerque, New Mexico). However, the overriding consideration for the CCRFCD was its insufficient funding given the great need to construct flood control projects. As a result, it was decided that as much work as possible would be contracted out to local agencies and the private sector and that CCRFCD staff would be kept to a minimum (five FTEs in FY 86/87, increasing to 12 FTEs in FY 90/91). Thus, existing city and county resources and private firms will be relied upon to provide maintenance, engineering, construction management, legal, and other functions, whereas the CCRFCD will provide planning as well as project and contract management services.

Citizen Concerns and Public Awareness

The concerns of citizens and public interest groups took on added significance in this project because the final master plan had to be approved in a general election. Therefore, an exhaustive survey of local citizen groups was conducted to identify key public issues and acceptable solutions. Three of the more important concerns that surfaced were: 1) incorporation of open space and recreational benefits into flood control projects; 2) use of as many natural, unlined channels as possible; 3) preservation of the lower Las Vegas Wash in a natural state. There was strong local desire for a project similar to the "Indian Bend Wash" project in Scottsdale, Arizona. However, these citizen concerns directly conflicted with the desires of most public works officials, who preferred lined channels and single-use facilities in order to minimize maintenance and public safety problems. A concerted effort was made to find an acceptable balance in the master plan between these
conflicting desires.

Because of the importance of citizen approval of the master plan, the project team included a public relations consultant who assisted in interpreting local needs and presenting the plan to citizen groups and public officials. The consultant proved invaluable in bridging the gap between engineers and laymen. The engineers, public relations consultant, and CCRFCD staff attended over 200 meetings to present the flood control plan to local citizen groups, service clubs, professional societies, and public agencies.
FIFTY YEARS OF FLOOD DAMAGE REDUCTION: A PITTSBURGH PERSPECTIVE

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Summary

The Pittsburgh region is well acquainted with floods. Despite warnings by Indians, the earliest pioneers in the area built where they pleased—near the rivers. Their early decisions resulted in the creation of Pittsburgh—a major urban industrial area highly susceptible to disastrous flood losses. The strategies developed to deal with flooding in the area are traced in this chronological review, which emphasizes the period following the St. Patrick's Day Flood of March, 1936, and the Flood Control Act of 1936.

Introduction

Historically, the Pittsburgh region along the Allegheny, Monongahela, and Ohio River Valleys in the upper Ohio River watershed is no stranger to flooding and its consequences. Disastrous flooding, such as that experienced in the Pittsburgh area, can severely affect an area's development unless comprehensive flood damage reduction measures are implemented.

The Pittsburgh "Point" and "golden triangle" area is a nationally recognized historical location that demonstrates the results of 50 years of flood damage reduction, both structural and nonstructural. The region provides a case study of urban growth and the resulting conflict between economic development forces and environmental/geographical concerns.

The earliest pioneers were warned of floods by local Indians, who pointed up into trees to show where they had once tied their canoes. But the pioneers disregarded these warnings and built where they pleased, near the rivers where water was abundant and provided access to markets. These decisions resulted in an industrial boom and the birth of a major urban center on the one hand and disastrous flood losses on the other.

A History of Floods and Flood Mitigation in the Pittsburgh Point Area

Public and private flood damage reduction efforts are traced in the following chronology of the Pittsburgh Point development over the last 250 years:

Pittsburgh Point in the 1700s

Figure 1 is a rendering of the Pittsburgh Point area in the early 1700s; the natural floodplain at the juncture of the three rivers is relatively untouched by
settlement. The contrast between this scene and the scenes of development that follow is dramatic.

Figure 2 is a rendering of the Point area in the 1750s, and shows Fort Pitt, Fort Duquesne, and the minimal surrounding structures. The basic intent of this settlement was security and control of the area and not development.

There exist historic flood records and writings on the floods of 1754, 1757, 1762, and 1763. "Many houses drove away and ye new banks of ye fort broke down very low. Many goods wet and damaged, ye water getting into ye magazines has I believe wet all ye ammunition and our powder also," wrote Quaker trader James Kennedy while the January, 1762 flood was receding from Fort Pitt. His cellar was full of water, everything in the village around the fort was covered with mud, but Kennedy was thankful because he hauled his trading goods to safety in a canoe and no one had been drowned by "Ye Deluge or Inundation."

In a 1762 post-flood report, Colonel Henry Bouquet said the flood got into the fort through drains and sally ports and even boiled out of the ground, washing away earthen revetments and floating the barracks down the Ohio River. Seneca Indian refugees, crowding into the village after the flood to ask for assistance, told Bouquet that great floods seldom occurred at Fort Pitt. However, surely the Indians remembered the ice flood of 1754 in which George Washington nearly drowned trying to cross the Allegheny and the flood of 1757 that nearly reached the rafters of cabins in the village around French Fort Duquesne.

Another 1762 post-flood report on damages at Fort Pitt was prepared by Colonel William Eyre, Chief Engineer to General Jeffrey Amherst. Eyre found the earthen escarpments of the fort washed out and tumbled down; he recommended they be revetted with brick before another inundation carried them completely away. He said buildings inside the fort had been flooded to a four-foot depth, and he recommended "flood proofing" by raising the first floor of the buildings at least five feet off the parade ground. Because protective measures would be costly and might be undone by a higher flood, Colonel Eyre suggested that Fort Pitt be abandoned and the garrison moved across the Monongahela River to the top of Coal Hill, Mt. Washington.

The 1800s

Figure 3 shows that by 1817, pioneers had progressed from securing and controlling the area with forts to settling the area for development. The quarters and buildings of livelihood of those early pioneers were beginning to form a community. Pioneers worried little about floods. In fact, it appeared they welcomed high
The Pittsburgh Point Area--1700 to March, 1936
Pittsburgh Point Area--March, 1936 to 1986
water for they could get their produce to markets more easily when floods covered rocks, snags, and shoals that impeded low water navigation. The pioneers called such lowland inundation "pumpkin floods" because their principal losses were bottomland crops.

Newspaper accounts of the February, 1832 flood called it the highest ever. Certainly, it was the most damaging to that date and was thought a major calamity. Frame houses were washed away, brick homes cracked, factories and mills were closed. Damages amounted to $200,000 in 1832 currency. One foolish businessman had built a factory on Smoky Island at the mouth of the Allegheny River; both factory and island disappeared during the flood.

Early records indicated that floods occurred on one stream or another in the headwater district almost every year. Most were forgotten a month after the water subsided, but the unique and significant floods were remembered: the remarkable double flood of 1852, the "barrel flood" of 1865, the record flood of 1867, the "Butchers Run" flood of 1874, record flooding in 1884, and the July, 1888 Monongahela River flood. The barrel flood was so named because Oil City, then a booming petroleum town, was flooded to the hills, and thousands of barrels, oil derricks, and drill rigs, as well as several bridges, were swept down the Allegheny River. The Butchers Run flood of Sunday, July 26, was an extremely large flash flood that killed some 150 people.

In 1884, editors of the Southern Lumberman wrote:

The trouble seems to grow worse every year. Each time the river gets higher. This is one of nature's ways of punishing man. For generations, armies of settlers have been occupied in cutting the timber along the banks of the Tennessee, Ohio, Monongahela, and Allegheny Rivers. The mountain sources of these streams have been stripped of the trees—their natural covering. The result is ruinous. The trees which hindered the rush of waters, which absorbed much of the moisture of melting snows, are gone. No longer are the waters impeded. They rush in floods, carrying everything before them, and Dame Nature is avenged.

The Valentine's Day flood of 1884 was particularly devastating throughout the Ohio River basin. The U.S. Army Corps of Engineers provided the first public disaster assistance by passing out food, blankets, and other items from Army boats. This flood also created new interest in reservoirs for flood control. During surveys of the upper Allegheny River basin, potential reservoirs were sited on the Mahoning, Redbank, Tionesta, Kinzua, Potato, and Conewango Creeks. However, it was not clear that such an investment would be worthwhile. Moreover, Congress was not prepared at
that time to undertake a massive flood control program, and many congressmembers doubted that such a program would be legal under the Constitution. Public clamor for some flood protection measures was so intense, however, that in 1884, Congress took its first (hesitant) step toward control of floods in the Ohio River basin. Since the constitutionality of federal navigation projects was no longer seriously questioned in 1884, Congress directed the Corps of Engineers to improve Ohio River navigation by raising and strengthening several local flood protection levees along the river. The Corps objected to the hypocrisy of building levees for flood protection on the pretext of improving navigation, but Congress was adamant, and the work continued.

In 1889, the Johnstown dam failure disaster killed 2,209 people. When the dam failed, it released a huge flood wave that followed already swollen streams and smashed its way down the Conemaugh Valley, ripping up trees, wiping out villages, and engulfing entire trains. A mass of debris was rolling on the flood crest when it hit Johnstown at the juncture of Stony Creek and the Little Conemaugh River. The city was almost completely destroyed by the deluge and ensuing fire.

Figure 4 demonstrates the considerable early, unplanned growth in the Point area. There is considerable economic and social urban sprawl, and indiscriminate development without guidance or planning.

Early 1900s

By the turn of the century, floodplain management concerns were still not being addressed (Figure 5). There were only the early cries for conservation of forest lands, soil erosion control of farmlands, and the growing public concern for death and destruction caused by floods. However, public outcries arose after the January, 1907 and March, 1913 floods, and a privately funded Pittsburgh Flood Commission report in 1912 proposed flood control reservoirs. At the same time, President Roosevelt declared that it was unconscionable that millions were being spent for relief of flood victims, but not one cent to solve flood problems, and that the federal government must build reservoirs to conserve flood waters to use for irrigation, hydroelectric power generation, and low-flow augmentation for navigation and other purposes.

Forestry and conservation enthusiasts won a major battle in 1911, when Congress enacted the Weeks Appalachian Forest Act, which approved federal-state cooperation in acquiring lands at the headwaters of the Allegheny and Monongahela Rivers and other areas as forest preserves. The stated purpose was to preserve the navigability of
rivers. By the time the great St. Patrick's Day flood inundated the Pittsburgh area in 1936, the federal government owned some 1.25 million acres of forest lands in the Allegheny and Monongahela uplands.

In 1930, industrial boom and business growth was continuing unchecked (Figure 6), and flood control dams were being strongly advocated. Frank Lloyd Wright had even developed a vision for the Pittsburgh Point of the future (Figure 7). However, in March, 1936 the Point was devastated by the highest flood of record in the upper Ohio River basin (Figure 8). Over ten feet of water covered the street-level floor of Horne's Department store (Figure 9). The 1937 flood, one year later, is still the highest flood of record on the lower Ohio River basin--Cincinnati and south (Figure 10).

**Flood Control Act of 1936**

Although Congress had been considering a flood control program for years, the devastating flood of 1936 resulted in the people demanding protection, and the Flood Control Act was passed by Congress on June 22, 1936. It stated:

> It is hereby recognized that destructive floods upon the rivers of the United States, upsetting orderly processes and causing loss of life and property, including the erosion of lands, and impairing and obstructing navigation, highways, railroads, and other channels of commerce between the States, constitute a menace to national welfare; that it is the sense of Congress that flood control on navigable waters or their tributaries is a proper activity of the Federal Government.

**1936 to the Present**

In 1945, major industrial and commercial development was occurring in the floodplain (Figure 11); railroad yards, an exposition hall and center, slum housing, and other construction all occupied the Point. The industrial boom of the war years had created a giant floodplain problem. Although many projects were slowed or suspended during the war years, ten local protection and seven flood control reservoirs had been completed in the Pittsburgh District by this time.

By 1950, the Point began to show the building and land use changes that accompanied the first city renaissance (Figure 12). The Pittsburgh District of the Corps of Engineers could now point to 12 local flood protection and eight flood control reservoirs completed as flood damage reduction measures (Figure 12). Moreover, developers of that time were beginning to recognize the flood hazard along the rivers and the Point.

The Flood Control Act of 1960 heralded the birth of floodplain management;
governments and developers were required to consider flood hazards before initiating any new development in flood-prone areas. The renaissance of the Point continued in the early 60s with the area being left open to provide transportation corridors, parks, historical landmark development, and other compatible uses (Figure 13). These efforts were further supported in 1968, when the National Flood Insurance Program was instituted by Congress and land use regulations were mandated to ensure lasting floodplain management.

The utility of these measures was demonstrated in June, 1972, when dramatic flooding of the Pittsburgh Point by tropical storm Agnes revealed significant flood damage reduction (Figure 14). The level of that flood was reduced by some 12 feet because of 11 flood control dams and reservoirs constructed upstream of Pittsburgh. By 1972, the Corps had constructed a total of 32 local protection projects and 14 flood control dams. Tropical storm Agnes did kill 122 people and cause catastrophic damages, especially in eastern and central Pennsylvania where the governor had to evacuate his Harrisburg mansion. Yet, the flood would have crested at Pittsburgh two feet above the 46-foot record stage set on the day after St. Patrick's Day in 1936, had it not been for the upstream reservoirs. More gratifying to the Corps of Engineers was the fact that not a single person died in the Pittsburgh District as a result of this flood (Figure 15).

The Pittsburgh District estimated that during the Agnes flood, its reservoirs had prevented $849,219,800 in damages—nearly four times what it had cost to build the projects. Adding local protection projects, the flood damages prevented were more than a billion dollars. Kinzua Dam on the Allegheny alone, built at a cost of $108 million, prevented approximately $247 million in damage downstream. In fact, the District Engineer, in 1976, reported that Pittsburgh District projects had provided flood control benefits aggregating five times their costs, not including other, less quantifiable benefits such as recreation, navigation, and water quality.

Today

To date, in the Pittsburgh headwater region—composed of the Allegheny, Monongahela, and upper Ohio River watersheds—that includes 26,000 square miles of drainage in five states, the Corps has constructed 23 navigation locks and dams, 16 flood control reservoirs, and 40 local flood protection projects. The Point area of Pittsburgh now includes an open park, elevated highway corridors, historic and landmark development, waterfront recreation uses, a state park museum, and has become an all-around community gathering area for the public. Thus it is an urban area that
nonetheless reflects the natural assets of the rivers and their banks and also the hazards of the floodplain. The area is a true example of floodplain management and comprehensive flood damage prevention planning that incorporates both structural and nonstructural reduction measures—upstream flood control reservoirs, local flood protection projects, floodproofing, land use regulations, local and state floodplain management regulations, conservation areas for detention, storm water management plans, flood warning and emergency procedures systems, and other measures (Figure 16).

In summary, in 1986—the tenth anniversary of the founding of the Association of State Floodplain Managers, the 25th anniversary of the Flood Control Act of 1960, and the 50th anniversary of the Flood Control Act of 1936—the Pittsburgh Point area well demonstrates the history of flood management in the U.S.

Yet that area and headwater region, although well-managed, is ever changing and the reduction of flood hazards is never complete. The recent flood disasters of November, 1985 in the Monongahela River basin and the May 30, 1986 flash flooding in the Little Pine Creek Watershed demonstrate that there is more work to be done.

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Photographs courtesy of the Carnegie Library of Pittsburgh and Pittsburgh Photographic Library.
FLOODPROOFING APPLICATIONS IN THE GOLDEN TRIANGLE AREA

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Summary

The major business section of the City of Pittsburgh, locally known as the "Golden Triangle" (Figure 1) incorporates numerous examples of private floodproofing, some of national prominence. This paper looks at the conception, design, and implementation of floodproofing systems at five structures, most notably at the Joseph Horne Department Store and the Pittsburgh Press Building.

Fort Pitt Museum

Through dioramas, exhibits of artifacts, models, reconstructed rooms, and live interpretive programs, the Fort Pitt Museum portrays the battle for control of the American frontier and the earliest years of the City of Pittsburgh. The museum was constructed in 1964 in Point State Park as part of that area's renaissance reconstruction program.

The area is vulnerable to flooding even during modest flood stages. The museum is constructed of reinforced concrete on a pad, and without intentional flooding, it would float. Therefore, given the adequate flood warning forecasts and lead times available to the area, a scheme was designed for completely removing all contents of value (many of the artifacts are priceless and irreplaceable). Having stored at each exhibit the appropriate containers and packing materials needed to transport the items, a group of approximately 20 staff and volunteers can remove the contents and prepare the building in about eight hours. Although the evacuation, cleanup, and restoration would not be without cost, it was felt that the additional foundation preparation needed to insure a watertight structure would not be cost-effective (Figures 2-4).

Gateway Center Parking Garage

This large, underground structure provides an excellent example of wet floodproofing. Resting on and situated in the alluvial soils at the mouths of the Allegheny and Monongahela Rivers, the lowest level of the garage is three feet below the normal pool levels maintained for river navigation and approximately 25 feet below grade. Long before overland floodwaters would enter the structure through the vehicle entrance, large foundation pressures would develop from even a 10-year flood. To relieve these forces, 10-inch relief pipes collect groundwater at four locations.
below the structure and discharge it into the garage. A sump pump system then removes the water prior to cleanup and resumption of operation (Figures 5-7).

Gateway Center Office Complex

These four high-rise office buildings adjoining the Hilton Hotel (site of the 1986 ASFPM conference) are no longer in a high-risk flood area because of upstream flood control works. However, this was not the case in 1950, when development began and so measures were incorporated into the building's design to achieve a watertight, structurally stable condition in case of flood. These measures consist of heavily reinforced foundations and various closure assemblies to prevent overland floodwaters from entering the lower level parking garage and electrical-mechanical shops or the first floor levels of each building. Utility adjustments control sewer backup and permit sump collection and ejection of water from foundation drains (Figures 8-11).

Pittsburgh Press-Post Gazette Building

This landmark building, constructed in 1927, experienced severe losses during the record St. Patrick's Day flood of March, 1936. Subsequently, an extensive floodproofing system was established, consisting of glass flood walls, steel flood shields for numerous and varied openings, electrical and mechanical adjustments, sewer utility modifications, and a flood preparedness plan. Modernization of appearance and operation over the years has required modification of some of these features to continue the protection as originally designed (Figures 12-15).

Joseph Horne Co. Department Store

This 19th-century structure was first occupied by the Joseph Horne Company in 1893 and first suffered flooding in March, 1907. At that time, the store was completely surrounded by shallow water, but wooden bulkheads and sandbags at the doors and display windows kept water out as seepage and under-floor drainage was pumped out of the basement. Subsequently, steel flood gates were provided for the display windows and entrances that were capable of protecting the structure against a 40-foot flood stage. The St. Patrick's Day flood of March, 1936 provided the first test of this system. However, as the water rose, the flood gates were left stranded in the middle of the Sixth Street bridge while in transit to the store from a remote storage location. Their arrival and installation would have been of no use, however, since the flood crested at 46 feet--six feet above the protection level--and
Floodproofing in the Golden Triangle Area
Floodproofing in the Golden Triangle Area
submerged the store in ten feet of water.

The floodproofing system now in place is a comprehensive system providing protection against floods even higher than 46 feet—an extremely remote possibility given current upstream flood control. However, the system, its design, and plan of execution remain a model of sound self-help floodproofing.

The system is complex and originally required the preparation of a flood manual designating responsibilities for 85 different crews. It required the installation of a glass tube gauge in the building, indexed to river stage, for monitoring flood levels and triggering corresponding activity. This activity could range from sewer and water adjustments and the movement of merchandise to the complete closure of every exterior opening; and, until the mid-1960s, the system was fully exercised every year.

The sophistication of the Joseph Horne system is apparent from an inspection of the display window flood shields, some of which span 25 feet. These large aluminum shields are constructed of plates fastened to vertical structural members and form
the backdrop for each display space. When needed, they slide forward and are bolted onto the interior window frame which is permanently fitted with bolts and gaskets (Figures 16-20).

References

Joseph Horne Company


The following personal interviews were conducted to research, verify, and photograph the floodproofing systems discussed in this chapter:

Peter Jobe, Equitable Engineers, Gateway Center Parking Garage, May, 1982.
Albert Clies and Peter Jobe, Equitable Engineers, Gateway Center Complex, February 25, 1986.
Robert Freeauf, Joseph Horne Department Store, October 15, 1982.
Bill Watt and Tommy Moore, Joseph Horne Department Store, June 3, 1986.
PART THREE
COASTAL FLOODPLAIN MANAGEMENT
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LONG-RANGE MANAGEMENT CONSIDERATIONS ASSOCIATED WITH COASTAL HIGH HAZARD CONSTRUCTION STANDARDS

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Introduction

The purpose of the National Flood Insurance Program (NFIP) has been clearly stated: "flood hazard mitigation through reducing the amount of property exposed to damage from flooding" (FEMA, 1983). This is accomplished, in large part, by the regulation of construction and development in flood hazard areas. The adoption of stringent construction standards by state and/or local governments provides the mechanism through which flood hazard mitigation is achieved. However, when applied to highly dynamic coastal landforms such as coastal dunes, beaches, and barrier beaches, this approach presents a long-range problem for coastal managers. Buildings are constructed to survive the 100-year coastal storm as the landform on which they are located responds to ongoing geologic processes such as storm-induced erosion and/or overwash. This paper will explore this problem by presenting a case study of Peggotty Beach, a barrier beach on the Massachusetts coast.

Storm Susceptibility

The Massachusetts coast is exposed to two types of storms: hurricanes and northeasters. Southerly facing portions of the coast are most affected by the former. Although hurricanes are a relatively infrequent type of storm, they move swiftly and strike the coast fiercely with wind speeds ranging from 74 mph (Category 1) to over 155 mph (Category 5).

Northeasters generally occur in New England with an average frequency of one or two per year. These are slow moving storms and the sustained winds of a northeaster can batter an exposed coastline for several days and through many tidal cycles. As a result of the sustained winds, surge heights can be in excess of five feet.

Sea Level Rise

In recent years a great deal of attention has been focused on projections that, as a result of increased atmospheric CO₂ concentrations, the "greenhouse" warming of the atmosphere would accelerate the rate of eustatic sea level rise. The Environmental Protection Agency (EPA) estimates that the historic four- to six-inch global sea level rise will increase to as much as five feet in the next century (Hoffman, 1983). A rise of this magnitude will result in many changes to the ecosystems of the coastal zone. One of the greatest impacts that will occur will be to barrier beaches. The response of barrier beaches to relative sea level rise is
well documented in the literature (Leatherman, 1984). As rising sea level increases the frequency of barrier overwash, sediment is transported from the beachface toward the backbarrier shoreline. The net result of this process is barrier transgression—the slow landward retreat of the barrier system. The rate at which this retreat occurs can vary. If it occurs rapidly, homeowners in close proximity to the shoreline can witness the rapid disappearance of the beach fronting their home.

Coastal High Hazard Construction Standards

When Congress enacted the National Flood Insurance Act in 1968, it was estimated that about 5,000 communities nationwide were subject to flood hazards. That estimate has now been raised to 22,000 communities (Gibson, 1984). In Massachusetts, 320 out of 351 communities participate in the National Flood Insurance Program (NFIP). Seventy-five of the 320 participating communities are within the Massachusetts Coastal Zone. Although this represents only 24% of the total participating communities, the number of policies in these communities amounts to 80% of the policies written and 79% of the total coverage in Massachusetts (Commonwealth of Massachusetts, 1983). These kinds of statistics clearly demonstrate the disproportionate risk associated with coastal areas.

The coastal floodplain is generally divided into two zones: a "V zone" and an "A zone." Each zone represents a different degree of flood hazard based on the height of the expected wave associated with the 100-year storm. V zones are the most hazardous areas of the coastal floodplain, and their landward boundary indicates the extent of a three-foot wave. An A zone represents an area subject to high velocity water but one in which the wave height is less than three feet. For this paper discussion will be limited to only the V zone or, as it is also referred to, the coastal high hazard area.

The Massachusetts State Building Code (780 CMR 744.0) requires, in part, new construction or substantial improvements within a coastal high hazard area to be certified by a registered professional engineer or architect that the following requirements are met:

1) The structure is elevated on adequately anchored pilings or columns, and securely anchored to such piles or columns so that the lowest portion of the structural members of the lowest floor is elevated to or above the 100-year level;

2) The structure is securely anchored as provided above, in order to withstand velocity waters and hurricane wave wash.
It goes without question that stringent construction standards like these are necessary to reduce flood damage and maintain the structural integrity of the building. The problem that arises, however, stems from the building's ability to withstand the forces of the 100-year storm while the landform on which it is built undergoes a transformation. Consider, for example, homes located in the V zone on a barrier beach. Because the homes are constructed on pilings and designed to withstand the 100-year storm, they will most likely survive such a storm with little damage. The barrier, however, has probably been overwashed throughout the storm and, as a result, has retreated landward. This results in an intact structure in closer proximity to mean high water. As the barrier retreats further, landowners begin to look for a remedy to the situation, usually in the form of structural protection (i.e., seawalls, revetments, etc.).

Peggotty Beach

Peggotty Beach is a partially developed bay barrier located on the coast of Scituate, Massachusetts. It fronts directly on Massachusetts Bay to the east and is backed by an extensive salt marsh to the west. The southern two-thirds of Peggotty Beach is developed, supporting single-family homes, utilities, and an access road. The northern one-third of the barrier contains a parking lot fronted by a narrow dune system.

Comparison of historic shorelines for this beach reveals that between 1876 and 1978, mean high water shifted landward by approximately 125 feet at the south end and 75 feet at the north (Commonwealth of Massachusetts, 1983). Considering the close proximity of homes to the shoreline, it is easy to see the age-old conflict of "people vs. the sea." Review of the storm damage history of this small barrier reveals repeated damage and destruction of homes. The most recent storm to cause such devastation was the blizzard of 1978. During that northeaster, 15 homes were totally destroyed on Peggotty Beach. These were homes built prior to the adoption of the floodplain standards of either the state building code or FEMA. When several of these homes were rebuilt after the blizzard, they were required to conform to the new standards. As a result, in the future these homes will probably ride out the worst of climatological conditions. The barrier on which they are located, however, will continue to shift landward at increasing rates, particularly if the EPA projections of sea level rise are correct.
Conclusion

Structural integrity of buildings located in flood-prone areas, even high hazard areas, can be preserved by using sound engineering design principals. The assurance of building survival, however, creates a long-range problem when the buildings are located on dynamic landforms such as barrier beaches. Although the building may survive a storm, the barrier literally rolls out from under the structure.

It is clear that measures must be taken now in order to avoid future problems that could prove to be very costly and environmentally damaging. Such measures should include:

1) Adequate funding of Section 1362 of the NFIA;
2) Prohibition of flood insurance to all structures located in V zones;
3) Expansion of the Coastal Barrier Resources Act to include V zones on all barrier beaches;
4) Upgrading of state and local floodplain regulations to prohibit construction in V zones;
5) The removal of state subsidies that encourage development in V zones; and,
6) The establishment of state acquisition fund for storm damaged property.

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Federal Emergency Management Agency

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THE FINISH FLOOR ISSUE

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We who deal with different groups, both socially and professionally, are acutely aware that the art of communication is that process whereby one individual passes to another--either through verbal or printed material--an idea, command, feeling, or desire. Many times, however, the idea transmitted is unclear or misunderstood because the recipient's perception of key words is different from the intent of the person making the delivery. To demonstrate this line of thought, I would like you to think of the word "peanuts." You may think in terms of like or dislike because peanuts are associated with several snacks and beverages, because they are salty, and so forth. However, the "Peanuts" which I am thinking of are not the ones you eat but the ones you read in the Sunday morning comic strip that contains the characters Charlie Brown, Snoopy, and others. As you can see from this brief example, the one key word "peanuts" projects to some individuals a vision of food, while to others, a completely different idea. This same problem occurs when individuals discuss matters concerning flood insurance.

One of the terms most commonly misconstrued when discussing flood insurance is the topic of this paper: the term "lowest floor" or "finish floor." This discussion attempts first, to present the working definition of "finish floor" that many enforcement officials use; second, to present the correct interpretation of that term and show why confusion occurs so easily; and third, to present the approach that one locality used to bring local interpretations into line with both floodplain management and flood insurance regulations and definitions.

Working Definition Often Used

Norfolk has operated, and it appears that other localities are still operating, under the impression or interpretation that the "lowest floor" is the lowest floor of a structure or dwelling that is a habitable space. This interpretation may or may not be correct!

Many localities ignore the floor elevations of garage areas and utility areas that are attached because these areas are uninhabitable as defined in building codes. This was the interpretation used by the city of Norfolk for many years. However, in the first half of 1984, as a result of questions raised by and subsequent discussions between insurance companies, local surveyors, and engineers from our city, a request
was made to the Federal Emergency Management Agency (FEMA) for a clearer ruling and definition of "lowest floor" (also referred to as "finish floor"). The response included cover letters and three separate bulletins that had recently been issued discussing, describing, and defining "lowest floor."

Correct Interpretation

Basically, one must look at "finish floor" or "lowest floor" from two separate but related viewpoints, and this is where confusion is very likely to occur. One must ask first, "Is the term being utilized in discussions for floodplain management?" and second, "Is the term being used for insurance rating purposes?" If it is being used for floodplain management activities, the floors of the attached garages are permitted to be below the base flood elevation, as long as that area is used exclusively for parking of vehicles. Any equipment such as hot water heaters, air conditioner units, heaters, etc., located in the area must be elevated above the base flood elevation, and the walls are not to be finished except when required by fire protection ordinances. Also, no plumbing or electrical fixtures are permitted below the base flood level.

The definition and discussion of "lowest floor" for insurance purposes generally follows these same guidelines. However, the major deviation and the crux of the problem arises because walls, if finished because of code requirements, would create an enclosed area. This would require that the "finish floor" elevation of a finished attached garage be utilized as the "lowest floor." Because of this, an apparent "Catch 22" situation existed in Norfolk, and I am sure it exists in many other localities. The Commonwealth of Virginia currently uses a Uniform Building Code that has been maintained since 1973. This code specifically requires that the walls between a dwelling unit and any attached garage area shall be at least "one-hour rated assembly" on the side adjoining the parking area. To achieve this one-hour rating, various methods are available. The most prevalent method is the attachment of 5/8" fire coded sheetrock to the garage side of the wall studs. Other methods which may be used are the application of a brick veneer with the bricks being at least four inches wide or, as an alternative, the continuing of the foundation wall as a solid wall to the underside of the roof. The last two methods are seldom used because they are extremely costly. Because sheetrock is susceptible to flood damage, if the sheetrock method is used on the wall of a garage whose floor is below the base
Brusso

flood elevation, a higher insurance premium would be applicable while, at the same time, FEMA floodplain management guidelines might be violated.

Norfolk, therefore, had two options. The first was to require that all garage areas have a "lowest floor" or "finish floor" elevation above the base flood elevation; the second was to seek a general variance from the requirements for this specific situation.

In Norfolk, which is basically an older developed urban area, approximately 95% of the land area has been developed. Perhaps as much as 25% of that land lies within the 100-year floodplain. A majority of the construction and alterations involve infilling and the rebuilding of areas designated as urban renewal areas. This renewal has primarily been in an area which has been declared "historic," and the new structures which are being built are required by local ordinances to be built within ten feet of the front property line in keeping with the older development. Also, because of the local floodplain ordinance and the mandated base flood elevation on the one hand and the elevation of these structures on the other, these buildings are usually required to be elevated above the existing grade approximately three to four and a half feet. Therefore, to have an attached garage, an individual would have to provide a driveway with a slope exceeding 30 degrees—an impracticality. Such a driveway would not only be impossible to use; it would also entail exorbitant construction costs, and the resulting structures would not reflect the historic nature of this community. The same general situation held true throughout several other 100-year floodplain neighborhoods in areas which were not designated "historic." It was, therefore, the opinion of city officials to seek a general variance regarding the "finish floor" elevation requirement but to ensure that the letter and spirit of the requirements of both the FEMA and the National Flood Insurance Program (NFIP) would be satisfied.

Remedy Used by One Locality

Each locality has distinct and different processes for allowing zoning or floodplain management variances. Norfolk's enforcement process for floodplain management is part of the zoning ordinance, and appeals for variances are made to the Board of
Zoning Appeals. This was the route which local enforcement officials wanted to follow.

Once this decision was reached, the first step was to create an effective line of communication between local officials concerned with the writing, amending, administration, and enforcement of the zoning ordinance (including the flood insurance program) and representatives from FEMA and the NFIP. Once communications were established, local officials then proceeded to establish a list of conditions that would have to be met by each individual to ensure the protection of the property and the safeguarding of the community should a general variance applicable to the situation be granted.

These draft conditions were then forwarded to FEMA for review. Their approval was obtained in November of 1984, and the matter was then ready to be heard by the Board of Zoning Appeals, which had opted to wait for FEMA's approval of these conditions. At a public hearing, the Board of Zoning Appeals approved a general community variance to allow garages attached to structures to be built with the garage floor below the base flood elevation as long as the following conditions were met:

1) The walls shall offer material resistance to flood damage to a point above the base flood elevation. This is achieved by maintaining a solid foundation wall to a point above the base flood elevation. At that point, the conventional wood stud wall with sheetrock or gypsum sheathing is permitted.

2) All mechanical, electrical, and plumbing fixtures and equipment shall either be located elsewhere in the structure or elevated on platforms above the base flood elevation.

3) The owner must sign a statement that this area will not be used for habitable space. (This condition was implemented to ease the strong feelings expressed by NFIP officials that garage areas were being converted to habitable spaces, thus increasing potential costs in the event of a flood.)

4) There must be a notation on all the plans and permits that a substantial increase in applicable flood insurance rates may follow as a result of the structure being constructed with the garage floor at a point below the base flood elevation.

5) Foundation type vents must be installed at a rate of one square foot of opening for every 100 sq. ft. of area in the garage portion of the structure. These vents are required to be constructed so that they will remain open, thus relieving the hydrostatic pressure occurring during a flood.
The city of Norfolk chose to establish this community variance for several reasons. One was to prevent an increased workload on the Board of Zoning Appeals due to increased individual applications. It appeared that approximately 24 individual applications would be received immediately with an undetermined number to follow. Another reason was to avoid a three- to four-month Board of Zoning Appeals processing time which applications usually encounter. Yet another was to give prospective home builders an option and to prevent the exorbitant construction costs or delays in redevelopment that would result should individuals be required to elevate garages above the flood elevation.

Since December of 1984 when the Board of Zoning Appeals' action became official, six structures have been completed with the "lowest floor" of garages below the base flood elevation. These structures were designed and constructed in accordance with the conditions outlined previously. Several similar projects are also being considered or are in the planning stage, but will not proceed until financing becomes available. Those structures on which construction had begun before the ruling went into effect and which were constructed in accordance with the interpretation previously held by the city of Norfolk have been reviewed to assure compliance with the local ruling.

Conclusion

In conclusion, although much has been said concerning the "lowest floor" elevation, much confusion still exists. This paper attempts to present the correct interpretations currently utilized by both FEMA and the NFIP, and to show an approach used by the city of Norfolk that might be useful to other urban floodplain professionals. Again, the requirement that all enclosed areas with finished walls--regardless of their use--be considered in determining the "lowest floor" elevation is the requirement of the NFIP. That all portions of a structure which are enclosed and contain equipment be elevated above the base flood level (or that the equipment itself be above the base flood level) and that walls be made resistant to flood damage are requirements of FEMA's floodplain management program. Should these conditions not be met, a violation does exist. One should also be aware, however, that if allowed, variances could cause increased insurance premiums.
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INTEGRATING STATE COASTAL POLICY INTO MUNICIPAL ZONING REGULATIONS IN NEW JERSEY

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New Jersey has 124 miles of shoreline along the Atlantic Ocean and 45 municipalities along this shoreline. Thirty-three percent (41 miles) of shoreline is categorized as critically eroding, while only 11% is non-eroding. With the exception of several parcels of state and federally owned park land, most of the shoreline immediately behind the beach, and in some cases the beach itself, is available for development.

In order to prevent development in hazardous areas and on protective shoreline features such as dunes and beaches, the state has adopted stringent coastal policies through its coastal zone management program. These policies are used to guide decision making for state permits. They preclude development on beaches, dunes, coastal bluffs and in rapidly eroding areas. However, the state does not have regulatory jurisdiction over residential development of less than 25 dwelling units. Unfortunately, such small residential developments predominate in oceanfront areas, largely due to the already dense development along the oceanfront and consequent land availability, and also due to a desire to avoid state regulation. An attempt to increase state jurisdiction through new legislation regulating development in dunes failed miserably in 1980. Therefore, development has continued in areas subject to severe flooding and storm damage, and dunes continue to be destroyed.

These problems led the state to seek alternative ways to incorporate state policies into development decisions. Without new legislation, the means seemed to be to incorporate the policies into local zoning ordinances and thus into land use decisions.

Although some municipalities have voluntarily adopted dune and beach conservation ordinances in the past, most have not done so or the ordinances are extremely inadequate. However, most oceanfront municipalities do look to the state for shore protection assistance, i.e., for funding of such activities as beach nourishment programs and repair and construction of shore protection structures such as bulkheads, groins, jetties, and sea walls, which are common along our coastline. The state is currently distributing $50 million in bond monies for shore protection and an additional $2 million specifically for dune restoration work. In addition, we anticipate that the state legislature will soon pass a bill providing a stable
funding source for shore protection. This is likely to accrue $15 million per year, to be distributed by the state's Department of Environmental Protection (DEP). Thus the state has money to offer municipal governments. Last year we decided to ask for something in return: compliance of municipal ordinances with state policy.

Specifically DEP revised its rules (administrative code) for the Shore Protection Program. We now require that, in order to be eligible for shore protection funds, a municipality must adopt and enforce ordinances in compliance with state policy in four areas: beaches, dunes, erosion hazard areas, and public access to the shorefront. These rules do not force a town to adopt such ordinances unless the town wants state shore protection funding.

At present, this rule has been applied to three major shore protection projects: a $5 million beachfill in Atlantic City; a $1.25 million jetty repair in Avalon; and a $436,000 bulkhead repair and reinforcement in Stone Harbor. In each case, staff of the DEP reviewed municipal ordinances for policy compliance and identified necessary changes. The towns' agreements to make these changes were a requirement to receive money and are being included in the state-local government contracts or aid agreements. For example, Atlantic City must adopt a dune ordinance, downzone a hazardous inlet area, and institute a conservation zone on the inlet beach. All of these areas could be developed under current zoning. Although some city council members opposed the dune ordinance, the $5 million project has proved to be sufficient incentive for agreement. Compliance remains to be seen.

Avalon and Stone Harbor must tighten up existing dune ordinances, which presently allow bulkheads to replace dunes and do not accurately reflect the presence of dunes due to failure to update zoning maps (a common problem). Both communities have proceeded to do so, with state assistance in drafting language and testifying at municipal hearings and council meetings. We have found our participation at public meetings and direct contact with officials essential for municipal action. Neither of these towns has balked at the requirement, perhaps because of the large sums of money involved with these projects and perhaps because they are anticipating a 1987 beach nourishment project. However, despite progress in obtaining ordinance changes, and (apparent) municipal agreement, we are finding problems in the implementation of ordinances. In Avalon, several projects in the dunes moved ahead rapidly to avoid review under the new ordinance. Currently, we are working to prevent the construction of seven stores on beaches and dunes. The formal agreement now provides critical leverage directing the town to prevent construction. Close monitoring of
enforcement of ordinances has become essential in all municipalities.

The DEP is also distributing smaller sums of money ($10,000-$70,000) to municipalities for dune restoration. We have yet to see how effective this program will be. One city has turned down the funds ($10,000) as not warranting the trouble of changing ordinances. However, several others have seized the opportunity to strengthen their ordinances and are delighted to have this excuse to finally enact such ordinances and to blame enactment on the state. As word of this regulation has spread, other government agencies have become involved, almost as watchdogs. For example, the state's Office of Floodplain Management works closely with municipal officials and thus often learns of small-scale projects (one to several houses) in dunes. In such cases, they notify officials that approval will potentially jeopardize shore protection funding and notify the DEP as well so we can act accordingly. County governments are also becoming involved and use failure to comply with shore protection aid agreements to deny permits.

The possible loss of shore protection funds has been used in several cases by local zoning and planning boards as reason to deny proposed projects in sensitive areas. The DEP has also stressed to municipalities that such ordinances could aid them in receiving post-storm federal disaster assistance. In particular, the report of the Interagency Hazard Mitigation Team following Hurricane Gloria included a recommendation that approval of Damage Survey Reports for beach, sand dune, or shoreline protection or restoration projects be contingent upon local adoption of acceptable beach and dune management programs. Thus the program is also effective in accomplishing federal hazard mitigation objectives and should speed up review and receipt of aid for complying municipalities.

Because these rules were only adopted in April, 1985, it is still too early to determine their long-term effectiveness. Several municipalities have agreed to make ordinance changes, have proceeded to draft revised language, and begun procedures to adopt the revisions. However, the real measure will be the enforcement of the ordinances and the frequency with which variances are granted.
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STATUS OF THE COASTAL BARRIER RESOURCES ACT
AND THE SECTION 10 DRAFT REPORT TO CONGRESS

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This paper discusses the study required by Section 10 of the Coastal Barrier Resources Act (CBRA) of 1982. CBRA resulted from recognition by Congress and the federal administration that the rapid development of coastal barriers since the Second World War has resulted in substantial loss or damage to valuable natural resources, greatly increased risks to life and property, and a substantial drain on the federal treasury because of assistance provided for the development, redevelopment, and protection of development on the barriers. The act has three purposes; they are to minimize 1) loss of human life, 2) wasteful expenditure of federal revenues, and 3) damage to natural resources. These purposes are to be accomplished by restriction of federal expenditures within specific geographic areas designated by Congress as part of the Coastal Barrier Resources System (CBRS). In the CBRS there are currently 186 units totaling over 670 miles of shoreline and over 450,000 acres within 15 states on the Atlantic and Gulf of Mexico coasts. These areas have been determined by Congress to be unprotected, undeveloped coastal barriers.

The key to CBRA is elimination of federal expenditures for new development within the CBRS. Section 6 of the act does allow certain exceptions for repair of infrastructure, conservation activities, and military and Coast Guard activities after federal agency consultation with the Fish and Wildlife Service. However, private, local, and state expenditures are not affected. Moreover, the taking issue has no legal validity, because a land owner has the freedom of taking personal risk.

Section 10 of CBRA directed the Department of the Interior to conduct a three-year study to make recommendations to Congress concerning: 1) the conservation of the natural resources of the CBRS, based on an evaluation and comparison of all management alternatives, and 2) additions to, or deletions from, the CBRS. To accomplish this task the Secretary of the Interior established a departmental study group under the leadership of the National Park Service, with representatives from the Fish and Wildlife Service and the Geological Survey, as well as other appropriate entities. Other federal agencies were also invited to provide input, and four recognized coastal barrier processes experts were hired to act as regional coordinators.

With the concurrence of the secretary and key congressional members, a decision was made to inventory all undeveloped coastal barriers on all coastlines of the
United States, including the Great Lakes. The study included otherwise protected barriers, secondary barriers within major embayments, coastal land forms functioning as barriers—including keys, mangroves, and consolidated sediments—and all associated aquatic habitat. As part of the management alternatives requirement, major areas of evaluation included:

1) State, local, and private conservation and protection initiatives,
2) Impacts of the federal tax structure,
3) Impacts of the exceptions allowed by CBRA,
4) Federal permits,
5) Impact of development adjacent to CBRS units, and
6) Redevelopment of areas outside the CBRS that are substantially destroyed by natural disasters.

This phase of the study only involved information collection; no recommendations were developed. The objective was to stimulate discussion and comment, and we succeeded admirably.

Inventory maps were developed using whatever information was available within available resources. These sources included aerial photography and information from states and federal agencies. Draft maps were sent to the 32 affected states and territories, and state coordinators, designated by the governors, were asked to review the maps. Members of the study group met with 17 state coordinators to review the maps and make adjustments within study guidelines. We identified 1335 units—totaling over 7,750,000 acres and 4,500 shoreline miles—as provisionally qualifying under the guidelines.

A March 4, 1985, Federal Register notice announced the availability of the maps and text of the study for public review and comment. The governors and congressional delegations of the affected states were supplied with copies of the study. At the request of Congress, the public comment period was extended from July 15 to September 30, 1985. During the public comment period, members of the study group were available for state sponsored public meetings, and they attended 25 meetings in ten states. The meetings were also attended by state and federal agencies. As required by Section 10, the Secretary of the Interior requested the views of all affected governors. Responses were received from all but four states and territories; in total, over 2,500 comments were received.

Of the 15 states now in the CBRS, ten are generally favorable to expansion of the system, although many expressed concerns about specific categories or areas—particularly the impacts of including otherwise protected barriers. One state did
not respond, and the balance prefer the status quo or deletions. Of the three Atlantic Coast states not presently included in the system, two favor accession. In the Great Lakes, two states favor accession, four oppose, and one did not respond. All west coast states are opposed to being included in the CBRS. Generally, those states already in the system and with the most stringent state laws are most favor­able to CBRA and its expansion and strengthening.

A majority of local communities expressed opposition to expansion of the system because of the perceived threat to development and to subsequent expansion of their tax base. As with the original act, the position of interest groups remained the same; conservation and League of Women Voters groups are favorable to expansion, development organizations are opposed. Responses from individuals were heavily in favor of expansion. However, there appears to be a continued misunderstanding of what the law does or, perhaps more importantly, does not do—particularly in states outside the CBRS.

As a result of state, federal, and public comment, plus the requirements of Section 10, Interior Secretary Hodel will propose recommendations. These recommenda­tions will be published in the Federal Register for 90 days of public comment. Again, federal agencies and governors of affected states will be specifically invited to comment, and congressional committees will also be briefed. Following the close of the comment period, a final report will be submitted to Congress. Let me empha­size that it will contain recommendations only. The Department of the Interior has no authority to implement these recommendations. Action by Congress through amend­ment of CBRA is required to expand or contract the Coastal Barrier Resources System or modify any provisions of the law.
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PART FOUR
FEDERAL PROGRAMS, THEIR USE AND THEIR FUTURE
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Local governments can and do play an essential role in implementing effective mitigation both before and after disaster events. One excellent example of successful mitigation sponsored by a local government occurred in Fort Wayne, Indiana. After suffering major floods in 1979 and 1982, Fort Wayne implemented a range of mitigation measures including a flood fighting and warning plan, an evacuation plan, and a flood contingency plan which included floodproofing and dike improvements. These measures were responsible for reducing flood damages from $55 million in 1982 to $7 million in 1985, when a comparable level of flooding occurred. Community interest and support was identified as the most essential element contributing to the success of this mitigation strategy, with federal, state, and local coordination being the second most important factor. Many other successes have occurred, although they are not widely known. It is clear that local support and action is nearly always the key to successful mitigation either before or after a disaster.

This paper explores three ways in which local government can become involved in postdisaster mitigation processes: first, local government can participate in the Interagency Hazard Mitigation Team process; second, it can contribute to Section 406 hazard mitigation planning; and, third, it can initiate predisaster mitigation planning. Because successful mitigation, particularly nonstructural mitigation, inherently requires local government action and support, local governments have come to play a critical role in the implementation of federally mandated postdisaster mitigation initiatives. Nonstructural mitigation, which typically involves the implementation of codes, ordinances, and regulations, requires local government action to develop and enforce these controls. In fact, 17,000 communities have adopted such regulations as part of their participation in the National Flood Insurance Program. Even structural mitigation, such as the construction of a Corps of Engineers or Soil Conservation Service flood control project, requires local initiative and support.

It is important to realize that federal disaster assistance as defined in the Disaster Relief Act of 1974 (PL 93-288) is by law supplemental to state and local capability to respond to a disaster. Consequently, each year many disasters strike states and local communities for which no federal disaster assistance is provided or even requested. For individuals and communities suffering from these undeclared
disasters, the impact can be extremely severe, however small their losses may appear on a nationwide scale of disasters. Even in the event of a federal disaster declaration, state and local government and the private sector must bear substantial recovery costs; the trend has clearly been to reduce the federal share of disaster assistance. For example, the portion of federal disaster assistance for eligible public facilities has gone from 100% to 75% (25% state and local) in recent years. Regulations proposed by the Office of Management and Budget stipulate a 50/50 cost share. At any cost, however, dollars cannot make up for loss of life and the anguish and disruption caused by a disaster. Mitigation measures which can reduce these painful losses reap their greatest benefit where they can best be implemented—at the local level.

Interagency Hazard Mitigation Team Process

Local governments have the opportunity to get involved in mitigation in federally declared flood disasters very soon after the disaster strikes by participating in Interagency Hazard Mitigation Teams (IHMTs). These teams, which were created in response to a 1980 Office of Management and Budget memo, take an interagency, interdisciplinary, and intergovernmental approach to determining hazard mitigation opportunities following floods. Team findings are presented to all interested agencies and units of government through a report published 15 days after the disaster event, and are followed by a 90-day progress report.

The fact that these teams are interagency, interdisciplinary, and intergovernmental is essential to their success, and the interagency agreement clearly states that the team leader will arrange state and local participation on the team. Moreover, the interagency agreement states that in terms of compliance, the regional director of FEMA shall require a state agency and a local agency to provide ongoing local leadership in implementing the 15-day IHMT report. In fact, there is seldom a recommendation which does not ultimately involve local government action. At some point, either through enforcement of a state statute or a federal regulation, or through support of a flood control structure, local government must become an advocate if mitigation is to be successful.

Interest in hazard mitigation and team operations has increased significantly in some states. For instance, the states of Louisiana and Maryland recently formed state hazard mitigation teams which work with and parallel the activities of the IHMTs. The Louisiana team was first activated for the October, 1984 flooding in that
state (FEMA-728-DR). The Maryland team was activated after the November, 1985 flooding though a federal disaster assistance declaration was not made for Maryland for that flood. Adequate state and local participation on the IHMTs, which is so critical to the mitigation process, can be effectively obtained through these state mitigation teams. State and local governments, after all, have a vested interest in the IHMT reports, because these reports help form the basis for the Section 406 hazard mitigation planning required of state and local governments receiving federal disaster assistance.

Section 406 Hazard Mitigation Planning

As a condition of receiving federal disaster assistance, Section 406 of PL 93-288 requires states or local governments to evaluate the natural hazards in the disaster area and take steps to mitigate those hazards. The specific requirements of Section 406, including the requirement to prepare and submit a Section 406 hazard mitigation plan within 180 days of the disaster declaration, are set forth in Subpart M of the FEMA regulations (CFR 44). Subpart M is now under revision. Most of the proposed revisions pertaining to the local role in the postdisaster mitigation process are very similar to current practices in many FEMA regions and serve primarily to clarify and strengthen the logical role of local government in this process.

The Section 406 plan is the key document guiding the state and local government long-term mitigation effort; it identifies critical mitigation actions. Section 406 plans will vary depending on the specifics of the disaster and on whether or not the state has a current, approved 406 plan. For those states which have such a plan, a 406 update may simply be required. The hazard mitigation requirements are intended to complement the ongoing land use management and building and development control practices of state and local governments. While a disaster presents a unique opportunity to implement mitigation measures during the short- and long-term recovery periods, FEMA recognizes that daily development decisions made by local governments have greater long-range impact on that community's vulnerability to disasters. For this reason it is crucial that Section 406 plans consider these ongoing routine community development processes in their mitigation strategies.

In addition to evaluating natural hazards in the disaster area, the hazard mitigation plan should include a description and analysis of current state/local hazard management policies/programs/capabilities. This analysis should review such
things as:

1) Land use planning and zoning practices;
2) Construction codes and building requirements;
3) Capital improvement programming;
4) Warning and evacuation systems;
5) Hazard awareness and public information/education programs;
6) Public works programs for hazard control and damage prevention;
7) Fiscal policies; and,
8) Any other laws, statutes, or ordinances which affect public safety, protection of the environment or other issues related to hazard reduction, avoidance, and mitigation.

The analysis and evaluation of hazards provides the basis for development of the hazard mitigation strategies, programs, and recommendations which make up the hazard mitigation plan. It is clear from a review of the above factors, all of which are local government activities, that mitigation can and must take place at the local level. Even federal or state mitigation actions such as state floodway regulation or federally funded and locally maintained flood control structures, require local support if they are to be effectively managed. It is for this reason that the proposed Subpart M regulations require local participation in postdisaster mitigation planning.

Predisaster Planning

Although disasters do offer unique opportunities for mitigation, especially through vehicles such as the IHMT process and Section 406 plans, mitigation opportunities are often lost in the rush to recover and return to normalcy. Following any kind of disaster there is a natural tendency to concentrate on meeting basic human needs and restoring basic public facilities. There is very little time to wrestle with complex, controversial, or costly mitigation solutions, such as acquisition and relocation or adoption of upgraded building and construction standards. One of the primary obstacles FEMA has identified that prevents effective mitigation following a disaster is the lack of planning prior to the disaster to guide recovery so that the potential for recurrence will be minimized.

Communities can do very effective predisaster mitigation planning at relatively little cost. For example, the Village of Kampsville, Illinois, received $5,000 from FEMA's Hazard Mitigation Assistance Program, $2,400 from the National Flood Insurance Program State Assistance Program, as well as a great deal of local support, to develop a very fine predisaster mitigation plan. Kampsville, a small community
(population 425) located on the Illinois River, has suffered frequent and severe flooding, normally during the spring snow melt and flood season. Implementation of the mitigation plan has already begun with funding from FEMA's Section 1362 Property Acquisition Program ($382,000), from the Illinois Division of Water Resources ($200,000) and from the Illinois Department of Commerce and Community Affairs Community Development Assistance Program ($324,000). Thus, a total of $906,000 has been granted to implement this plan.

Predisaster mitigation planning is valuable not only to guide redevelopment after a disaster occurs, but also to promote day-to-day decision making discouraging additional hazardous development. In fact, the most cost-effective time to implement mitigation planning is prior to development and investment in costly infrastructure, rather than after loss of life and/or property and the creation of an opportunity for redevelopment. Section 406 plans, although they occur after a disaster, are, in fact, predisaster plans designed to be implemented before the next disaster strikes.

Conclusion

In summary, local governments must be aware that they play an essential role, in fact the most essential role, in promoting mitigation both on an ongoing basis and as a participant player in FEMA's postdisaster mitigation activities. Though everyone benefits from cost-effective mitigation, local government, business, and private citizens are the primary beneficiaries, particularly when mitigation occurs before a disaster strikes. All too often, however, local government planners and decision makers fail to consider hazards as land use plans, zoning ordinances, construction codes, and development regulations are formulated and implemented. In part, this may occur because local floods and other hazards tend to be seen as acts of God rather than predictable events in which damages can be controlled. Additionally, state and local officials may still feel that federal disaster assistance provides a cushion against debilitating losses, though, as mentioned earlier, federal disaster assistance is neither guaranteed nor free.
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FLOODPLAIN MANAGEMENT ACTIVITIES OF THE BALTIMORE DISTRICT, CORPS OF ENGINEERS

George N. Fach, Jr.
U.S. Army Corps of Engineers, Baltimore District

Introduction

One means by which the Corps of Engineers can contribute to the strengthening of local flood protection programs is through its Flood Plain Management Services (FPMS) Program. This program, authorized by the 1960 Flood Control Act, is the Corps' means of providing planning and technical assistance on flood and floodplain-related matters. In authorizing this program, Congress recognized that every community could not qualify for a federal flood control project and that the ever increasing number of structural projects was not reducing the nation's flood losses. Congress saw the need for programs to guide the use and development of floodplains to avoid future flood hazards.

Activities Under The FPMS Program

There are three main areas of involvement under the Corps' FPMS Program: technical services, planning assistance, and preparation of guides and pamphlets.

Technical assistance activities concern the development, interpretation, and dissemination of flood and floodplain related data. Types of data include: velocity, depth, frequency, stage, elevation, and areal extent of flooding. We can also address the environmental, cultural, and economic aspects of flooding and floodplains.

Planning assistance activities make up the most diverse area of our program. Here assistance can be provided to develop and evaluate a full range of floodplain management and flood damage reduction measures. Some of the measures we work with are floodproofing, flood warning, emergency preparedness, and flood insurance.

The third major area of involvement is in developing guides and pamphlets. This includes conducting studies of improved methods of flood damage prevention and preparing reports, guides, and pamphlets to assist all levels of government and the general public in reducing their flood damages.

FPMS Program services are provided at no charge to the requestor; however, the involvement of the requestor in providing data is encouraged.

The remainder of this paper presents examples of innovative activities undertaken by the Baltimore District.
Flood Stage Inundation Mapping

A very popular activity of the Baltimore District's FPMS Program is flood stage inundation mapping. The resultant maps show the areas in a community that will be affected at various flood levels and the corresponding stages that will occur for each level at a nearby stream gauge. The value of these maps is that they can be used in conjunction with flood forecasts from the National Weather Service (NWS) or locally operated systems to determine areas that will be flooded. Information on areas that will be flooded is valuable in the planning and execution of emergency response activities. Thus, flood stage inundation mapping can be used by local emergency management and community officials, businesses, and individuals to develop and carry out emergency plans--including establishing damage reduction measures, determining evacuation procedures and routes, controlling traffic, and designating mass care facilities. Maps can also be educational if made available to the general public. The Baltimore District has prepared flood stage inundation maps for 20 reaches of stream covering a total of more than 100 miles.

Flood stage inundation maps are, very simply, a plan view representation of a series of vertical water surface profiles. Different flood levels can be delineated by different degrees and patterns of shading or different line patterns. Each flood level is labeled with the corresponding flood stage reading that will occur at the selected nearby stream gauge. There are three prerequisites to preparing useful maps:

1) Base topographic mapping (1" = 200' or 400' and a 2' or 5' contour interval work best). These do not have to be line-drawn maps; orthophoto maps can be used successfully.

2) Water surface profiles for a range of floods. We have used available data from FEMA, Corps, and SCS.

3) A quantitative flood forecast and warning capability. Someone (NWS or local government) must be able to predict flood stage at a nearby location and be able to issue a warning in time for emergency action to be taken.

If mapping or water surface profiles are not available, the cost to develop these data would be prohibitive. If a quantitative flood forecast is not available, the maps are useless. Without a forecast, there is nothing to react to. The cost of preparing flood stage inundation maps ranges from $250 to $1500 per mile and depends on the degree of sophistication chosen for graphics.
Flood Damage Reduction Surveys

One of the specialties of the Baltimore District is our flood damage reduction surveys for communities, businesses, and industries. These surveys are intended to provide realistic recommendations for actions which can be taken to reduce flood losses. We feel that our surveys of individual businesses and industries are an important activity because they help local governments achieve their goals of economic stability and floodplain management. The Baltimore District has conducted 30 surveys since 1979 for such diverse entities as metal and textile products manufacturers, a food processing plant, aircraft repair and manufacturing facilities, a plant nursery, industrial parks, a shopping center, and waste water treatment plants.

Flood damage reduction surveys are conducted by a team of representatives from different agencies and different backgrounds. The agencies currently participating are the Baltimore District, Corps of Engineers (we act as chair and organizer of the team); Region 3 of the Federal Emergency Management Agency; the National Weather Service (Harrisburg, Pennsylvania and Washington, D.C.); the Susquehanna River Basin Commission; the Pennsylvania Departments of Community Affairs and Environmental Resources; SEDA-Council of Governments (a central Pennsylvania-based regional economic development organization); and the Maryland Water Resources Administration. The local agency requesting assistance also participates on the team.

The interagency team has expertise in the following methods of reducing flood losses:

- Floodproofing--assessing the effects of modifications to the site, building, and equipment to reduce susceptibility to damage.
- Emergency Preparedness Planning--analyzing the effects of flooding and formulating a response plan to reduce those effects.
- Structural Protection Measures--evaluating the traditional solutions: dams, levees, flood walls, and channel modifications.
- Evacuation Planning--identifying the physical changes, organization, and equipment needed to move vulnerable items to a safe location prior to a flood.
- Flood Forecast and Warning--establishing the means to detect, quantify, and disseminate information about potential floods before they occur.
- Quick Recovery of Operations--planning the manpower, equipment, and supplies needed to resume business in an efficient manner.
- Flood Insurance--evaluating insurance not as a loss prevention measure, but as a means for providing financial compensation and spreading the risk.
Together, these measures form a comprehensive set of tools that can be used to reduce the effects of flooding.

The first step in conducting a survey involves a representative from the FPMS branch and the local requesting agency meeting with company officials to determine if a survey by the full team is warranted. When the team is mobilized for a survey, they meet with company personnel to obtain background information and then conduct an on-site inspection of the facility to see where and why flood problems occur. After that inspection, the team meets to discuss ideas and formulate tentative recommendations. If some issues cannot be resolved at that time, appropriate team members are assigned to conduct the additional analyses or research to obtain the information needed to make a decision.

It is then the team's job to compile all of the information into a final report which is forwarded to the company through the local requesting agency. Once the company has received the team's recommendations, a follow-up meeting is held to explain them and to discuss future actions and possible sources of assistance. The whole survey process takes four to six months from the time of the initial meeting until the follow-up meeting. The time involved from the company's viewpoint is minimal--between two and four hours for the pre-survey meeting and the tour of the facility.

Guides and Pamphlets

The Corps has performed special studies and prepared publications on a variety of topics relating to flood damage reduction. One such activity conducted by the Baltimore District concerned waste water treatment plants (WWTPs). As a result of major flooding in the 1970s, the Pennsylvania Department of Environmental Resources requested assistance in reducing flood losses at WWTPs. Damages to Pennsylvania WWTPs from floods in 1972 and 1975 totalled $6.8 million, and some facilities were inoperable for up to one year.

The interagency flood damage reduction survey team was mobilized for this effort. The whole team surveyed six plants, representing different types and sizes of facilities and different regions, and individual team members visited several more. The results of our study were published in a report entitled, "General Recommendations and Procedures for Flood Damage Reduction at Wastewater Treatment Plants." Several thousand copies have been distributed to federal, state, regional, and local agencies, architect-engineer firms, and foreign governments. The study
resulted in several significant observations and recommendations.

First, it was observed that current practices involving siting (i.e., near a watercourse), layout (i.e., elevation to achieve gravity flow and location of facilities below ground), the type and location of equipment, and choice of construction materials were factors contributing to the susceptibility of WWTPs to flooding. It was also found that existing federal and state design requirements address flood resistance to a limited degree. Research revealed that the Environmental Protection Agency requires the purchase of flood insurance on WWTPs, but that the National Flood Insurance Program excludes predominantly below-ground facilities. We also found that WWTP operators were not experienced or trained in flood emergency preparedness.

Recommendations for flood damage reduction included making changes in new facility designs to reduce susceptibility, instituting measures to facilitate emergency response actions (i.e., evacuation), and taking steps to qualify for flood insurance. To address existing WWTPs, information was provided on floodproofing, flood protection, and emergency preparedness. The team also recommended and participated in the conduct of formal training for WWTP operators.
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HAZARD MITIGATION ACTIVITIES AND PROPOSED CHANGES:
FEDERAL EMERGENCY MANAGEMENT AGENCY DISASTER ASSISTANCE PROGRAMS

Patricia K. Stahl Schmidt
Federal Emergency Management Agency

The following outline details three important aspects of the Federal Emergency Management Agency's involvement in hazard mitigation: 1) proposed Disaster Assistance Program (DAP) regulations, 2) proposed legislative amendments to the Disaster Relief Act, and 3) DAP mitigation programs administered through the Comprehensive Cooperative Agreement (CCA).

Proposed DAP Regulations

I. Revised Public Assistance Regulations (key provisions) (44 CFR Part 205 Subpart C)

A. Proposed regulations published April 18, 1986
B. Federal assistance is by law only supplemental to state and local disaster assistance.
C. OMB has directed FEMA to seek a 50/50 cost share.
D. FEMA has proposed indicators to determine the relative capability of states to handle disaster losses.
E. The chief indicator is per capita personal income.
F. FEMA will assume that states can handle $1.00 in losses per resident; this amount will be multiplied by the per capita state income and divided by the national average per capita income to adjust for states with a higher or lower per capita personal income.
G. Other factors—such as state or local hazard mitigation efforts—will be taken into consideration when FEMA decides whether or not to recommend disaster declarations to the President.
H. This formula will result in fewer declarations and therefore may indirectly result in mitigation.
I. Once a declaration is made, a sliding scale based on per capita losses will be applied to public assistance applicants so that the federal share will range from 0 to 90%.

II. Revised Hazard Mitigation Regulations (44 CFR Part 205 Subpart M)

A. Proposed regulations published April 18, 1986
B. These regulations clarify the scope and content of state hazard mitigation plans required under Section 406 of PL 93-288.
C. The law requires local government participation in postdisaster hazard mitigation planning.
D. It also outlines steps for development, monitoring, and implementation of state mitigation plans.
E. It allows greater flexibility for disaster proofing.
Proposed Legislative Amendments

I. Disaster Relief Amendments of 1986 (FEMA 99-1A)
   A. Sent to OMB May 13, 1986
   B. Includes the following mitigation related components:
      C. Deletes "one bite free" on flood insurance. For flood disasters, the
         amount of public assistance will be reduced by the amount of coverage which
         the damaged facility could have had in force. This will encourage greater
         flood insurance coverage.
      D. Provides hazard mitigation funding on a 50/50 cost-sharing basis for
         mitigation projects totaling up to 5% of the total eligible public
         assistance funds for permanent restorative work.
      E. Provides for the recovery of funds by authorizing the Attorney General of
         the United States to initiate action against any party whose action or
         omission may have caused or contributed to damage for which federal
         assistance is being provided. This may encourage more cautious development
         in hazardous areas.

II. CCA Hazard Mitigation Programs of the DAP
   I. Comprehensive Cooperative Agreement (CCA)
      A. CCA is FEMA's funding vehicle to state and local governments.
      B. A "guidance package" for FY 87 is now being reviewed by the states.
      C. State CCA proposals were due to FEMA Regional Offices 7/15/86.
      D. CCA awards were made 10/1/86.
      E. Further information may be obtained from FEMA Regional Hazard Mitigation
         Officers (HMOs).
   II. Hazard Mitigation Assistance Program
      A. Delivered through the CCA to state and local governments.
      B. Anticipated FY 87 allocation per region is $18,000.
      C. Funds hazard mitigation planning and implementation.
      D. See FEMA HMO for additional information.
   III. Disaster Preparedness Improvement
      A. Delivered through the CCA to state and local governments.
      B. Provides $25,000 to states on a 50/50 cost-sharing basis.
      C. Funds activities which improve delivery of disaster assistance, including
         mitigation activities.
      D. See FEMA HMO for additional information.
   IV. Emergency Management Training
      A. Three new state and local mitigation courses will be offered through the
         FY 87 CCA.
1. A 2-3 day state hazard mitigation training course to be held in FEMA Regional Offices.

2. A one-day mitigation workshop to be held at a state for all state agencies.

3. A one-day local mitigation workshop to be held with individual communities or with a group of communities.

B. See the state training officer or FEMA HMO for additional information.
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THE SOIL CONSERVATION SERVICE AND FLOODPLAIN MANAGEMENT

Donald von Wolffradt
USDA, Soil Conservation Service

SCS's Floodplain Management Studies
The Soil Conservation Service's ability to carry out floodplain management activities is now impaired because one-half of the water resource planning staff has been eliminated. Thus, our ability to provide assistance when requested has been severely hampered.

Current Activities
However, the Soil Conservation Service will be providing rural communities with floodplain management information in the form of both publications and assistance.

Soil Conservation Service floodplain management studies include analyses of management alternatives. All of the floodplain management measures discussed in the "Unified National Program for Flood Plain Management" may be evaluated. Recently we have included individual flood audits which can increase the effectiveness of flood warnings, especially in upstream areas where warning times are short.

One state is currently converting resource data to a hydrologic data base. This is a significant step, for the first time making resource conservation data applicable to water quality and floodplain management programs.

Additional information on the Soil Conservation Service's activities and available services can be obtained from any SCS state office; the offices are located in each state capital or in communities that also contain land-grant universities.
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FLOODPLAIN MANAGEMENT AND THE EPA

Mary Lou Soscia
Office of Federal Activities, Environmental Protection Agency

Unlike other organizations like the SCS and FEMA, the Environmental Protection Agency does not have a well-defined program to coordinate with other floodplain management efforts. Although there are other parts of EPA that have regulatory authority related to floodplain management—especially the hazardous waste program—the discussion here is confined to issues related to wetlands.

The Office of Federal Activities has the responsibility within EPA for administering Section 404 of the Clean Water Act of 1977. Section 404 authorizes the Corps of Engineers, in conjunction with EPA, to regulate (on a case-by-case basis, through a permit program) discharges of dredge and fill material. As an extension of the 1972 Federal Water Pollution Control Act, permits are required for discharges into "waters of the United States" rather than just "navigable waters." Thus, the permit requirement is extended to all parts of salt water wetlands. For inland wetlands, jurisdiction includes all waters to which the Commerce Clause of the Constitution applies.

The Section 404 responsibilities of the Office of Federal Activities revolve around policy and elevated cases and include: state coordination; research initiatives, such as our bottomland hardwoods work; and policy development. The recent controversial denial of a 404 permit by one of our assistant administrators for a shopping mall in North Attleboro, Massachusetts, was also the result of work by our staff.

I am a new addition to the federal bureaucracy, having spent seven previous years in state government, including floodplain management work for the states of Maryland and Wyoming. I was also very active in the ASFPM. I came into the 404 program at the federal level as an advocate for state and local views. I was also interested in bridging the gap between floodplain and wetland management; I recognize that some states, like Wisconsin, have well-integrated programs, but that is the exception rather than the rule. For instance, in Wyoming, local floodplain management administrators had no idea how to review a 404 permit; in fact, they did not even know if a review was necessary, even though most permit applications were for projects in the 100-year floodplain.

Coincidentally, as I was acclimating myself to the federal system, our administrator, Lee Thomas, formerly of FEMA, had designated wetland protection and management as a priority planning issue for the agency. As part of our strategy to
address this need, we targeted increased coordination with floodplain management programs and the Federal Emergency Management Agency. Previously there had been little coordination with FEMA, so we initiated a headquarters-level meeting with FEMA to exchange information on our respective programs. Pilot regional meetings were also set up with two of our respective regional offices, Seattle and Boston, and we currently look forward to holding such coordination meetings in all ten regions. At the same time, we are working to increase our presence on national level groups—the Floodplain Management Task Force and the Hazard Mitigation Task Force. Our hope is to make wetland management a major concern and part of every unified floodplain management planning process.

We are also negotiating a Memorandum of Understanding with FEMA. A draft memorandum has been prepared; however, the link between public safety (FEMA's concern) and resource protection (EPA's concern) needs to be made stronger. Nonetheless, we hope to be able to finalize an agreement in 1987.

EPA has also been working to increase coordination with the states. We recognize that the states play an important role in local implementation and, since wetland and floodplain management decisions always originate at the local level, that coordination with them is critical. We look forward to working with the joint floodplain/wetland committee of the Association of State Wetland Managers and the Association of State Floodplain Managers.

Some of the other issues of concern on our agenda include advanced identification and hydrology. Advanced identification is the process (which our regional offices are going through right now) of designating priority planning areas for future wetland management. The process can be coordinated with mapping done for the National Flood Insurance Program, and we look forward to working with the states and the ASFPM to gather advice and expertise as we pursue this new initiative.

We are also looking for stronger links between hydrology studies and wetland management programs—links similar to those resulting from the Charles River study done in Massachusetts. We have made a proposal to FEMA for joint research to identify these possible areas of overlap—our long-range goal being better management of wetland areas to achieve flood loss reduction goals. Increased cross-knowledge of floodplain and wetland management principles can only benefit both areas; the physical similarities between the two land forms underscores the necessity to coordinate these programs. The key to this coordination lies at the local level, with state and federal government enforcing regulations and providing technical
assistance when necessary. Officials at the local and state level are the experts and implementors; we in the federal government are the facilitators.
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CHANGES IN THE NATIONAL WEATHER SERVICE AFFECTING FLOODPLAIN MANAGEMENT

Curt Barrett
National Weather Service, Office of Hydrology

The National Weather Service budget for the next few years is expected to be relatively stable although the effects of the Gramm-Rudman legislation are still not certain.

The NWS is committed to improving river forecast and flood warning service by the implementation of new technology for the 1990s. We are in the planning phase of a modernization and restructuring effort to be implemented during that decade. This modernization effort consists of the development and implementation of new doppler radars as part of the multi-federal agency Next Generation Radar (NEXRAD) project. These new radars and processors will provide high resolution rainfall information and substantially improve our ability to detect flash floods. In addition, all NWS observations at airports will be automated. The Automation of Surface Observations System (ASOS) is expected to be operating in the early 1990s.

To collect, process, and display the vast amounts of remote sensing data--such as radar and satellite imagery data, automated local flood warning system data, and GOES satellite platform data--the NWS is also planning an Advanced Weather Interactive Processing system (AWIPS) to improve the effectiveness and productivity of NWS operations.

Associated with this modernization is a restructuring of the field offices of the NWS. This restructuring is based on the recognition that facilities and staff changes are required to make cost-effective use of new technologies and to improve services across the entire nation.
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WATER LEGISLATION PENDING IN CONGRESS

Mia O'Connell
National Association of Urban Flood Management Agencies

I would like to review current water legislation pending in Congress and, in particular, those provisions in the legislation affecting flood control projects. Beyond that, I would like to discuss new opportunities which may become available to floodplain managers, even in the era of cost sharing.

The premier pieces of water legislation in Congress over the last several years have been the omnibus water resources bills. The House of Representatives passed their legislation in November of 1985; the Senate passed their version in March of 1986. The two bodies first met in conference on June 6, 1986. That meeting was mostly procedural, the highlight being the appointment of Senator Abdnor as conference chairman. Senator Abdnor set the tone for the conference by indicating that as a first priority, the conferees would discuss the issue of cost sharing. He indicated that cost sharing really was the heart of the legislation and the provision that had moved the bills through the legislative process. He also said that if the conferees could not come to an agreement on cost sharing, there was no reason to continue to negotiate on the bill.

The cost-sharing provisions in the Senate bill were agreed upon last year after the Administration and the Senate leadership reached a compromise over new project starts. The Administration agreed to the new starts if the Senate would enact new reforms drafted by David Stockman and the Senate committee leadership. The Senate inserted the compromise in its legislation, but the House passed less stringent cost-sharing measures.

In the Senate bill, the required local contribution for flood control projects consists of all lands, easements, rights-of-way, and relocation—with no cap on these costs—as well as 5% of the total cost of construction (contributed toward the nonfederal share of 35%). The basic nonfederal share of 35% of project costs can be reduced to 25% when the 5% and all lands, easements, rights-of-way, and relocation are contributed during construction. Further, the 5% cash contribution can be waived proportionately for nonstructural projects. The Senate bill also provides for the reduction of the local cost-sharing burden based on an ability-to-pay provision. This determination would be made by the Army Corps of Engineers.

The House bill requires that the local contribution for flood control projects be all lands, easements, rights-of-way, and relocation, with a cap of 30% on the nonfederal share when lands, easements, rights-of-way, relocation, and the cash
contribution of 5% exceed 25% of project costs. The basic nonfederal share here is 25%. In addition, nonstructural projects are capped at 25%.

Both bills provide for 50% cost sharing with local governments for the development of feasibility studies; half of this nonfederal contribution must be made in payments. The House bill, however, provides that any contributions by locals to feasibility studies be credited against the nonfederal share of construction.

Both the House and Senate bills provide credit for work local sponsors perform and for costs incurred prior to authorization, if the work is compatible with the federal project. The Senate bill requires certification of compatibility with the federal project. Significantly, the House bill also calls for the Corps to study the nation's urban flood problems and to recommend changes in federal programs.

As a final note on cost sharing, it is safe to say that no matter what happens in conference, the final product will require a larger commitment of local funds than in the past. However, as discussed later, this change may provide new opportunities for local floodplain managers to obtain the projects they want for their communities.

The National Association of Urban Flood Management Agencies (NAUFMA) is now working on a compromise bill for the conference committee--particularly addressing the question of cost sharing for local flood control projects. The proposal would raise the basic nonfederal share to 35%, including the 5% cash contribution, but in no case would the local share exceed 50%. This 50% limit already exists in law, and, we feel, provides protection against land-intensive solutions and sky-rocketing land costs.

Another major piece of legislation now in Congress is the reauthorization of the Clean Water Act. The House passed their legislation in September of 1985, and the Senate passed theirs in June, 1985. The conferees have met several times since the spring of 1986. The issue of most significance to floodplain managers in this legislation is the storm water discharge permit requirements in both the House and Senate bills. The House bill requires storm water discharge permits for separate storm sewers and for discharges that violate a water quality standard. However, the bill allows a storm water permit to cover more than one separate municipal storm sewer.

NAUFMA, EPA, and city and county organizations have been working on a compromise for the conference committee on the storm water permit issue. As a result of these efforts, EPA recognizes that requiring a permit for every separate storm sewer may be prohibitively expensive for local governments and an administrative nightmare for the
agency. Therefore, EPA has worked out a draft position which NAUFMA is studying. This proposal would eliminate the requirement for across-the-board permits, and instead establish a short-term, immediate control requirement for problem discharges. In addition, it would provide a broad framework for a general storm water control program and would authorize EPA to issue regulations in consultation with states which set forth program details. These regulations would clarify responsibilities and tasks for each size and level of government handling discharge. For example, large municipalities would be required to collect storm water data to determine problem areas and then to develop a control program to address local problems.

Another issue of interest is pending disaster relief legislation. The 99th Congress has not been nearly as active as the 98th in enacting Disaster Relief amendments, in large part because the congressional committees of jurisdiction have been concentrating on the Clean Water Act, the water resources legislation, and Superfund legislation. Therefore, no major disaster relief amendments have come out of the 99th Congress, and it is unlikely that any will.

An issue of consequence not just to water resources people but to anyone interested in the federal deficit is the legislation known as Gramm-Rudman-Hollings. Congress passed that legislation in 1985. It legislates a balanced budget in five years by requiring Congress to meet budget deficit targets laid out in the legislation for each of the next five years. If Congress does not meet those benchmarks, a sequestration mechanism is put into effect. Sequestration involves automatic, across-the-board budget reductions affecting all federal spending.

At this time, both the House and Senate have passed their budget resolutions and the measures are in conference. Both bills meet the deficit target in different ways, but both include tax increases to reach the deficit benchmark.

If Congress does not meet the law's deadline by October under their own budget processes, then, under Gramm-Rudman, the President must issue a sequestration order which would take effect October 15. It is difficult to estimate what the budget cuts might be, but they could involve 20 to 25% across-the-board program reductions.

Congress included a fallback position in the law, if the Supreme Court found the automatic cuts unconstitutional. The provision calls for the development of a joint budget committee that would incorporate the cuts into one piece of legislation that would then have to be passed by Congress and signed by the President.

One final note: Although the reduction in federal revenues for water projects will affect many program administrators— including floodplain managers—and although
the new cost-sharing rules will require larger nonfederal contributions, the future of water project development programs need not be entirely dim.

The new cost-sharing rules and the flexibility in the pending water resources legislation can indeed afford local governments a greater say in project scope and design. For the first time, locals will be able to help determine study outcome and project characteristics, because they will be a part of the study process. In January of 1986, the Army Corps of Engineers issued new criteria concerning this matter. The new guidelines for cost sharing for feasibility studies emphasize a planning partnership between the local sponsor and the federal government, reflecting a new responsiveness to nonfederal concerns.

As a result, the relationship between floodplain managers and the Corps should change. Rather than projects fitting a national standard, they should be better tailored to local needs. Floodplain managers should now be able to look forward to helping to design and build projects which can blend into and take advantage of their existing community plans, whether they be in a rural or urban environment.
PART FIVE
TOOLS FOR FLOODPLAIN MANAGEMENT
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WATER CONSERVATION AS A FLOOD CONTROL MEASURE

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Introduction

The concepts of flood protection and conservation are not generally considered compatible. However, the thesis of this paper is that both may be achieved simultaneously in urban environments in arid and semiarid regions. Historically, municipal planners and engineers have handled storm runoff by disposing of it in the quickest and least expensive way; streets, storm drains, and natural or improved stream beds have been used to get the unwanted storm water "out of town." Commercial areas have been protected from the 25-, 50-, or even 100-year event, while residential areas have received relief from the two- to five-year event.

In the 1970s two new concepts in urban drainage management emerged. The first consisted of subdividing the storm water system into major and minor subsystems. Ideally, in such cases, the minor system is designed for the five-year event, while the return period for the major system is 100 years. Thus, the idea of different levels of protection for properties of different values has been replaced by a more uniform level of protection. The goal of the second concept was to prevent deterioration of flood protection in downstream areas following development of an upstream portion of the watershed. Such deterioration, due to both the increase in upstream impervious areas and the improvement of waterways, had resulted in increased peak runoff rates in lower areas and in quicker flooding. Ordinances of many cities now require a developer to provide a drainage plan which restricts the peak flow rate from a developed parcel to the rate that existed before development. A few ordinances also require that the volume of runoff not exceed the natural volume. Ingenious means of providing the required storage have resulted. Using recreational areas--tennis courts, baseball fields, etc.--as retention areas has become one popular solution. However, several problems with this approach have been reported, particularly concerning maintenance and ownership. A recent study (Lee, 1985) of a hypothetical basin indicates that the no-increase-in-peak-rate rule does not insure the intended protection for downstream owners. Rather, it shows that storm pattern and system geometry may combine to change the event from the design conditions so that peak or near peak flows arrive at the downstream area simultaneously with the
local flow, thus increasing the flood hazard.

**Storm Water as a Resource**

The storm water management approach described above implies little or no appreciation of the value of water in an arid or semi-arid region or in other areas where demands approach or exceed existing supplies. The typical municipality in the American Southwest has exhausted all cheap sources of municipal water. Groundwater close to cities has been developed; all legally available surface water has been utilized; and any additional source of water is probably distant from municipalities, requiring more expensive treatment than current supplies. Thus, additional water is almost always expensive. The water use pattern in these areas usually involves large demands during the summer months with much smaller demands in the winter. The summer excess is primarily used for landscape maintenance, a use which does not normally require treatment of the water.

Two possible alternative means to fulfill these peak demands exist. The first, and most obvious, is the reclamation/reuse of waste water. Although currently practiced to a limited extent, this approach has met with considerable resistance for a number of reasons; opponents object to the quality, aesthetics, health and safety, cost, etc. As a result, waste water reuse most likely will continue to be limited to industrial, agricultural, and occasional recreational and groundwater recharge applications.

The second, and usually overlooked, means is the utilization of storm water runoff. By capturing and storing significant quantities of storm water for landscape maintenance in residential areas, peak demands could be reduced, water conserved, and many storm water management problems mitigated. In short, this approach involves storm water being treated as a resource rather than as a liability.

Storage of storm water on each residential lot can provide benefits to the home owner, to the local water utility, and to the storm water management system. These advantages are discussed below. Because the benefits and the costs are not uniformly experienced by each of the three, there must be some sharing of costs; a method for achieving this equity is discussed at the close of this paper.

**Impact on the Home Owner**

When instituting a storm water retention program, a home owner can expect to
invest additional money in his or her property if storm water storage has not previously been provided. The extra costs arise because of both the storage vessel and the landscaping required. The storage vessel will most likely consist of a cistern located under the house or under the driveway and could be constructed of plastic or concrete. Access for cleaning, as well as a means of pumping the water for use on the landscape, must be provided. In addition, in areas of low rainfall, roof gutters will be required to enhance the water harvest; in other areas, the runoff from the roof can flow onto the lawn which, in either case, will have been provided with a low spot equipped with a drain inlet to the cistern. The driveway should contain transverse grooves to channel the water onto the lawn or into an inlet. In some areas, it may be appropriate to slope the sidewalk toward the yard to aid in runoff capture. The cistern must be equipped with a pump connected to the landscape watering system.

The owner can receive at least two benefits from this system. First, the amount of water purchased from the local utility will be considerably reduced—the exact monetary benefit depending on the rate structure of the utility and the type of landscape desired by the home owner. Second, in some regions the quality of the water used on the landscape will be improved.

Impact on the Water Utility

Municipal water supply systems include impoundment and intake structures at a source, conveyance and treatment mechanisms, and a distribution subsystem consisting of ground-level and elevated storage, booster pumps, and a distribution network. The goal of the utility is to provide as much water as the users demand at a pressure of 40 to 60 psi. To achieve this goal, the distribution piping must be sized for the maximum demand. As noted earlier, much of this demand is created by landscape watering requirements during the summer. During those months peak hourly demand is often five to seven times the average hourly demand.

The prime reason for elevating storage in the system is to obtain lower fire insurance rates. Elevated storage can also serve as a short-term source of supply and help maintain the system pressure. Ground-level storage, with its accompanying booster pumps, forms the backbone of the system. This storage may be designed to accommodate the maximum day when adequate elevated storage is present; otherwise, the pumps must be sized to accommodate the maximum hour. The supply pipes from the treatment plant to the ground-level storage can be designed using the maximum week if
the ground level storage is sufficient; otherwise, they, too, must be sized for the maximum day. The treatment plant must also be designed for the maximum day or week, depending on the amount of clear well and ground-level storage. Even the conveyance facilities from the source must be sized to meet greater than average flow requirements.

Thus, much of the capacity of the system is unused much of the time; again, a significant portion of that extra capacity is required to meet landscape watering requirements. If these requirements were met by storm water stored in cisterns located on individual lots, the size of most, if not all, of the system could be reduced. Since it is not practicable to actually reduce the size of existing facilities, the net result of implementing this plan is that a utility can delay building new facilities. The major costs to the utility would arise from the decrease in revenue needed to retire bonds issued for prior capital expansion; a sudden reduction in use could certainly cause serious financial burdens in some cases. Realistically, however, the plan would be implemented on new housing and would be integrated into the system slowly. Hence, the financial impact would be minimal.

**Impact on the Storm Water Management System**

Storage, as a means of storm water management, is a recognized method of damage mitigation. This plan differs from others because the proposed storage is "distributed," and is not designed to provide flood protection. Protection is only an incidental benefit; however, it is a sizable one. The decreased runoff resulting from this plan would impact all aspects of storm drainage: collection, conveyance, and disposal. The collection and conveyance system would only need to accommodate a reduced flow, and the disposal facility would similarly have to handle less volume at a smaller rate. These are particularly important considerations when the area being developed is upstream of existing developments not designed to accommodate increased flow. On-site storage could reduce the runoff rate and volume to essentially the amount produced from streets and other public facilities not requiring stored water. Thus, there appear to be no costs to the storm water management system for existing facilities, and new facilities would cost less because of the reduced capacity required.

The flood control capability of any storage device decreases as the amount of unused storage volume decreases. Thus, a storm water manager would have to be con-
cerned about the effects of a storm occurring when the cisterns are full. However, two important considerations are 1) since people will use stored water at differing rates, the probability of total unavailability of storage space at any one time is small except when two large rainfalls occur close together in time; and 2) if the catchment area (e.g. yards, curbs, etc.) are properly constructed, there will be additional storage available on the surface. In the latter case, the water would eventually infiltrate into the ground. Such surface storage would be unavailable only if a storm occurred when a cistern was full, and there had been insufficient time between events for surface water to infiltrate.

Maintenance of flood protection facilities is often expensive and therefore often neglected. The maintenance of the collection and storage system in this plan would directly benefit the home owner and thus should not present a problem.

Sharing the Costs

All the costs associated with this plan appear to fall on the home owner; all facilities are on his property and must be maintained by him. The benefits, on the other hand, are enjoyed by the home owner, the community at large, and, in particular, the developer. If the requirements of the drainage code are met by on-site storage, land which would otherwise be needed to provide storage could be developed and sold. This benefit notwithstanding, the developer could find the new homes difficult to sell because of their increased cost. This problem could be overcome by assessing the buyer lower water rates. This incentive, coupled with reduced water needs, could make the homes marketable. Additionally, in many arid regions, the quality of the cistern water would be superior, for landscape use, to that delivered by the water utility--an added incentive that could be used by the developer to aid sales.

Only the water utility itself could institute reduced water rates for homes equipped with suitably designed cisterns, and that would only happen if real benefits were forthcoming. Specifically, a utility would have to have some means of controlling the rate at which home owners take water from the utility system during peak demand periods. In times of local drought, the home owner whose cistern is empty will want to maintain his landscape with utility water. Unless the rate at which this water is withdrawn is limited, there would be negative benefits to the utility whose system has not been sized to accommodate this demand.
Control can be obtained by placing an orifice on the supply line at the entrance to the water meter. This orifice would be sized to allow a known flow rate at a given pressure. When system pressures are above this design value and the system is not stressed, more water could be delivered. Thus, the orifice would have to be sized to accommodate normal in-house water uses, but not those needs and outside uses; i.e., it would be sized for the winter use rate. During a drought, a home owner could elect to store utility water in his cistern at night to avoid reducing delivery rates during the day. Such action would not be detrimental to a well-designed water system. In addition, a utility could assess water rates based on the size of the orifice in the home delivery line; the smaller the orifice, the lower the unit cost of water. The costs to the utility for installation of the orifice would be negligible.

A storm water management system is financed by the public at large through some form of taxation. Because the system would be called upon to handle less water at a smaller flow rate, the costs associated with on-site storage should be shared by the public. One mechanism to accomplish this is the reduction of taxes on the property either for a specified period determined by the "payout" of the cistern system, or in perpetuity.

Research in Support of the Plan

The technical feasibility of this plan has been under study at Texas Tech since 1970. James D. Shanks (1978) studied the effects of various forms of storage in both residential and commercial areas and concluded that on-site storage is an effective flow control mechanism. Subsequently, runoff plots, consisting of a 14'x16' impervious area draining onto a 16'x20' grassed area, have been constructed. The grassed areas are configured in different ways to measure the effects of temporary ponding as well as cistern storage. At the same time, data are being obtained on the peak use rates at ten residences (spanning the socioeconomic range) in Lubbock, Texas. The data will be correlated with monthly water use figures to determine the size orifice needed to control the maximum delivery rate. A study is also underway to determine the storage requirement for a typical lot in Lubbock and the added costs of the suitably sized cistern. It has been found that an important parameter in this study is the ratio of pervious to impervious area.
Summary

The plan set forth in this paper to reduce the detrimental effects of urban storm water provides benefits to the home owner, the water utility, and the storm water management system. However, the costs would be almost entirely borne by the home owner. This inequity could be remedied if the water utility were to provide reduced rates to the home owner upon the assurance that the home owner would not add to the peak system demand, and if the storm water management system were to grant reduced taxes to the property owner in exchange for the storage of storm water. The plan is technically feasible, but implementation is prevented by the inaction of the water utilities and the storm water management systems. Some legal restructuring may be required to permit these two entities to offer the required incentives.

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A NEW APPROACH TO MODELING FLOOD FLOWS

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Introduction

The modeling of flood flows using the computer is an established practice among professionals responsible for flood control. Over the last two decades, many hydrologic procedures, methods, and techniques have evolved into practical models for flood computations, among them the U.S. Army Corps of Engineers HEC-1 model and the USDA, Soil Conservation Service TR-20 model. These are hydrologic computer models whose main objective is to convert a rainfall event of given depth, duration, frequency, temporal and spatial distribution into a flood event at a given location, described in terms of peak flow rate and associated flood hydrograph.

These models include two major components: 1) hydrograph generation at each subwatershed outlet; and 2) hydrograph movement through the stream network. For small watersheds of relatively simple topology, accuracy in flood flow modeling usually hinges upon the correct determination of the hydrograph generation component. For large watersheds, generally those with drainage areas exceeding 20 square miles, emphasis gradually shifts to the hydrograph movement. For watersheds of complex topology, the properties of hydrograph movement—i.e., translation, diffusion, and possible nonlinear effects— Influence the calculations and may well account for a large portion of the overall accuracy. For these watersheds it is therefore imperative that the stream channel routing component be modeled properly.

Given the pervasiveness of the computer, it is likely that bigger and ever more challenging flood flow modeling projects will continue to be undertaken in the future. This is certainly a healthy trend, but one that can only be sustained with ever more "friendly" models, that is, models that free the user from complicated instructions and let him concentrate on the physical meaning of the input/output. As the application size increases, the stream network topology grows increasingly complex, and conventional models become more cumbersome and often unmanageable.

With the above in mind, this paper describes a new way to model flood flows: the RAINFLO approach. Unlike conventional models, the RAINFLO modeling system has the following unique features: 1) diffusion wave stream channel routing capability, and 2) generalized topology enabling it to automatically simulate dendritic stream networks of virtually any size and complexity. Its diffusion wave nature gives the RAINFLO modeling system numerical consistency and increased predictive capability for simulating a wide range of flood flows. Moreover, the RAINFLO system is user-
Conventional Models

In order to appreciate RAINFLO's unique features, it is first necessary to review the conventional models: HEC-1 and TR-20. The HEC-1 model (U.S. Army Corps of Engineers, 1985) has the following options for flood routing: 1) Muskingum; 2) Kinematic Wave; 3) Modified Puls; 4) Working R and D; and 5) Level Pool Reservoir Routing. The Muskingum method is an option for stream channel routing, while the kinematic wave method is generally used to evaluate land surface runoff. The remaining methods are primarily used in reservoir routing. The Muskingum method is the classical method, with empirically determined routing parameters (reach travel time and weighting factor) which are kept constant and do not vary with the flow. The kinematic wave method features uncontrolled numerical diffusion, i.e., a diffusion-like behavior which is a function of grid size.

The HEC-1 model topology considers sub-basin runoff components (e.g., 10 and 20) and an associated routing reach 1020. The runoff from component 10 is calculated and routed to control point 20 via routing reach 1020. A suitable combination of sub-basin runoff and reach routing components is used to represent a stream network problem. The logical connectivity of the stream network is implied by the order in which the data is arranged. The simulation proceeds downstream until a confluence is reached. Before simulating below the confluence, all flows above that confluence must be computed and routed to that confluence. The hydrograph combination is performed manually by means of a sequence of instructions directing the program to combine certain hydrographs at certain locations.

The TR-20 model (USDA, Soil Conservation Service, 1983) uses the Modified Att-Kin method for its channel routing module. This routing method has replaced the convex method which was the routing module of TR-20 until 1983. The Modified Att-Kin method has better accuracy than the convex method, while remaining within the computational framework of the original TR-20 model. According to SCS, it is an interim procedure to be used until more complete channel routing models become available.

The Modified Att-Kin method consists of a two-step process in which the flood hydrograph is first attenuated by means of storage routing and then kinematically translated. The method calculates separately the diffusion and translation of flood hydrographs and then attempts to combine them while satisfying conservation of mass.
As with the HEC-1 model, the routing method has a linear structure, with empirically
determined parameters which are kept constant and do not vary with the flow.

Furthermore, its theoretical basis is unclear, and its diffusion effect intractable. Tests using the Modified Att-Kin model have shown lack of consistency (i.e.,
lack of hydrograph reproducibility with varying grid size), indicating the presence
of uncontrolled amounts of numerical diffusion.

The TR-20 model uses control statements to indicate the sequence in which flood
routings through the stream channels are to be performed. The control statements
cause a runoff hydrograph to be developed, to be routed through a structure or
channel reach, and to be combined with other hydrographs of intervening areas. For
example, a RUNOFF 1 statement causes an inflow hydrograph to be developed for the
area above structure 1; the statement RESVOR 2 causes the inflow hydrograph to be
routed through structure 1; the statement REACH 3 causes the outflow from structure 1
to be routed through the next stream reach. As with the HEC-1 model, the hydrograph
combination is performed "manually," with specific instructions required in sequen­
tial order. This limits the applicability of TR-20 to relatively simple stream
networks. The modeling of complex channel networks would have to be performed as a
combination of several simpler configurations.

In summary, both HEC-1 and TR-20 have topological structures relying on
specific instructions, and both suffer from substantial weaknesses (e.g., uncon­
trolled numerical diffusion) in their channel routing components. The RAINFLO
modeling system described herein attempts to address these shortcomings.

RAINFLO Channel Routing Module

The RAINFLO modeling system was developed as a hybrid channel routing tech­
nique--one exhibiting both hydrologic and hydraulic properties. The method is hydro­
logic in the sense that it resembles the Muskingum method with its emphasis on
channel storage and routing parameters, its focus on flows rather than on stages, and
its neglect of downstream effects. The method is hydraulic because the routing
parameters are calculated in such a way as to simulate diffusion wave routing, with
enhanced predictive capability for hydrograph translation and diffusion based on
channel gradient and cross-sectional data.

In essence, the method is as simple to use as the hydrologic methods but has a
predictive accuracy comparable to that of the more elaborate hydraulic routing
techniques. Being founded on diffusion wave theory, it is applicable as long as the
flood wave is a diffusion wave. Experience with flood computations has shown beyond reasonable doubt that diffusion waves are applicable in a wide range of practical flood situations.

The routing method in RAINFLO is the Muskingum-Cunge method (Ponce and Yevjevich, 1978). In a nutshell, the method is based on a discretization of the kinematic wave equation. A linearization technique enables the development of a diffusion wave equation, with two parameters: wave celerity and channel diffusivity. The discrete analog of the kinematic wave equation is expanded in Taylor series to obtain the numerical diffusivity. By matching this numerical diffusivity with the channel diffusivity, a predictive value for the weighting factor is obtained. To minimize numerical dispersion effects, the method is subject to a condition imposing an upper limit on the reach length (Ponce and Theurer, 1982).

In the RAINFLO routing module, the routing parameters are calculated based on channel characteristics (gradient and cross-sectional shape) rather than on historical data. This is a significant feature because it allows the parameters to either be kept constant or to vary with the flow. The latter may become important in cases with substantial overbank flow in which the routing parameters are likely to vary markedly as a function of stage. Moreover, this RAINFLO feature circumvents the need for historical streamflow data with which to effect a calibration, making it very appealing for channel routing in ungauged watersheds and basins. It also eliminates the need for transposition of channel routing parameters from the few reaches with records to the many without.

**RAINFLO Topology**

The RAINFLO modeling system has a generalized topological structure enabling it to automatically combine hydrographs at confluences, regardless of the network complexity. The user specifies the anatomy of the network in terms of 5-digit topological numbers containing stream order, branch, and channel information. Based on these numbers, RAINFLO orders the sequence of computations to enable the routing of flows through the network of stream channels and reservoirs. The hydrograph combination is automatic, based on the topological numbers, and without the user's having to specify which hydrographs are to be combined. Flood hydrographs are printed out in as many points of design interest as desired.
Control of Spatial Resolution

The issue of resolution accuracy is one that plagues many hydrologic computations using computer models. Generally, numerical reasons dictate that there be some relationship between the problem scale (e.g., hydrograph time-of-rise) and the grid size (reach length and time interval). The difficulty usually arises when a reach is too long for a given hydrograph, in which case a subdivision into subreaches is necessary. In conventional models this subdivision is accomplished manually and invariably requires a concomitant change in routing parameters. Otherwise, inconsistent results would be obtained (a different answer for a different grid size).

The above problems are eliminated in RAINFLO through its automatic control of spatial resolution coupled with its physically-based channel routing module. Channel reaches are automatically divided into subreaches as required to satisfy spatial resolution criteria. Unlike conventional models, in RAINFLO the routing parameters are a function of grid size, allowing them to change "at runtime" to accommodate the required reach subdivision while maintaining numerical consistency. It is this feature of RAINFLO which sets it apart from other hydrologic models.

Summary

RAINFLO is a new approach to hydrologic modeling. This modeling system combines a diffusion wave routing capability with a generalized topological structure, resulting in increased accuracy and friendliness, particularly when modeling complex stream channel networks. Input data is physical rather than historical, allowing the simulation of flood flows in gauged/ungauged watersheds/basins to a level of detail hitherto unmatched by alternative models. Moreover, the RAINFLO modeling system is user-friendly and fully documented.

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WS PRO: A WATER-SURFACE PROFILE COMPUTATION MODEL

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Introduction

The U.S. Geological Survey (USGS), in cooperation with the Federal Highway Administration (FHWA), developed WSPRO, a digital model for water-surface profile computations. WSPRO is a very easy to use model which is generally applicable to water-surface profile analyses required for highway design, floodplain mapping, flood insurance studies, and estimating stage-discharge relationships. This paper very briefly describes some of the model's features.

Input Features

Individual input data records, identified by one- or two-character codes, are similar to those used in HEC-2 (U.S. Army Corps of Engineers, 1981). The order in which the different data types are input is extremely flexible. Most input data can be coded in a "free-format" which can be tailored to suit the individual user. The order independence and "free-format" of the data greatly reduce the user's need to consult an instruction manual to assure adherence to rigorous coding conventions and specifications.

Data which do not change from section to section need only be coded for the first section to which they are applicable. Values for most missing data are automatically supplied by propagating those data from the preceding downstream cross section. Limited capabilities exist for synthesizing cross-sectional geometry from a template cross section. A template section can be expanded or reduced by a scale factor and/or be modified by removal of landward parts on either or both sides of the section. Elevation adjustments to account for valley slope are easily accomplished for either propagated or synthesized section geometry.

Default values are automatically provided for all parameters, test values, and tolerances that govern the computational procedures as well as many other coefficients that enter into the analyses. These default values are adequate for the vast majority of analyses, thus generally eliminating the need to code these data. However, when flow conditions so dictate, the default values can be easily overridden with user-specified values. Similarly, the user may choose to specify certain parameter values which are normally computed by the model. Therefore, when flow conditions being analyzed are not consistent with assumptions built into the model, unreasonable computed parameter values can be easily overridden by user-specified
values.

A series of alternative designs (e.g., different bridge openings and/or different road grade elevations) can be analyzed with a minimal amount of additional input data and in a single execution of the model. The only limit on the number of alternative designs is the amount of output that the user wishes to generate.

Output Features

Both the quantity and the type of information that is generated can be controlled by the user. A comprehensive summary of the profile computation results is available to permit the user to evaluate the validity of the analyses. Printer plots of cross section data and tabulations of the hydraulic properties of cross sections may be generated. Users may also design output tables which satisfy their individual requirements. Additionally, a wide selection of key input parameters and computed results are stored in a machine-readable, direct-access file, allowing users to develop software to access this file to generate additional tabular or plotted output.

Computational Features

General

Water-surface profiles can be computed for any flow situation that can be reasonably classified as one dimensional, gradually varied, steady flow. Computations can be performed in the upstream direction (for subcritical and/or critical flow) or in the downstream direction (for supercritical and/or critical flow) without physically rearranging the input data. Up to 20 water-surface profiles can be computed in a single model execution. Discharge can be changed at any section to account for varying flow. Initial water-surface elevations for each profile may be user-specified or computed. If slope is specified, the model computes the "normal" water-surface elevation using the slope-conveyance method. If neither elevation slope is specified, the model computes the critical water-surface elevation based on minimum specific energy.

Open-Channel Flow

Water-surface profiles for open-channel flow are computed using standard step-backwater methods (Chow, 1959) and are generally consistent with previously developed water-surface profile computation models. WSPro provides for simultaneous variation of channel roughness across a cross section and with depth of flow. Friction loss
computations permit the user to specify variable flow length between sections and/or to select the technique for averaging friction slope. The user may also specify the coefficients used to compute energy losses associated with expansion and/or contraction of flow between sections.

Flow Through Bridges

When the water surface does not have significant contact with bridge girders and flow is critical or subcritical, a free-surface flow profile is computed using the technique developed by Schneider and others (1977). This technique is a modification and extension of the USGS contracted-opening method (Matthai, 1967) which has long been used to compute discharge through a bridge. As in the original method, a coefficient of discharge, which reflects variations in the bridge configuration and geometry and certain flow characteristics, is computed for the bridge opening. The original method balanced the energy equation between two sections: 1) a section in the bridge opening, and 2) an approach section (located one bridge length upstream from the opening). The revised method simultaneously balances the energy equation at a minimum of three sections: 1) an exit section (located one bridge length downstream from the opening), 2) the bridge-opening section, and 3) the approach section. A fourth section reflecting spur dike geometry is included when appropriate. This procedure incorporates three other significant deviations from the original method. Friction loss between the approach section and the bridge is based on an estimated effective flow length which can be significantly greater than the straight line distance previously used. A "control" conveyance (reflecting the impact that flow distribution at one section may have on adjacent sections) is used in computing the friction loss for all subreaches. An empirical expansion loss is computed for the subreach between the bridge opening and the exit section. Shearman and others (1986) present a limited comparison of computed free-surface profiles using WSPRO, HEC-2, and E431 (Shearman, 1976) against observed water-surface profiles. Analyses reflecting six flood events at five sites indicated that WSPRO generally produced the best overall results.

When significant contact exists between the water-surface and the bridge girders, WSPRO computes pressure flow through the bridge. Two orifice-type flow equations presented by Bradley (1970) are used, one reflecting unsubmerged orifice flow (contact only with upstream girders) and the other reflecting submerged orifice flow (contact with both upstream and downstream girders).

Supercritical flow through a bridge can be analyzed by computing profiles in a
downstream direction. The bridge opening is simply treated as a regular cross section. More complex flow situations may require judgment regarding the coding of additional sections to obtain reasonable results.

Flow Through Culverts

Culvert computations reflect current design procedures of the FHWA (1982, 1980, 1979). Capability exists for analyzing single- or multi-barrel configurations of box, circular, and pipe arch culverts of concrete, corrugated metal, and aluminum construction. Culverts may be included in multiple opening analyses. Currently, WSPRO only permits "stand-alone" analyses of stream crossings having an individual (single- or multi-barrel) culvert installation. Analyses are limited to inputting discharge(s) and tailwater elevation(s) with culvert data to compute headwater elevation(s). Revisions are planned which will permit continuous water-surface profile computations through such installations.

Flow Over Embankments

Embarkment overflow is computed as broad-crested weir flow (Bradley, 1970). Embarkment overflow in conjunction with free-surface flow through the bridge is analyzed as follows: 1) assume an upstream water-surface elevation; 2) compute the resultant embankment overflow; 3) subtract embankment overflow from the actual discharge to obtain flow through the bridge; 4) compute an upstream water-surface elevation for the flow through the bridge; and 5) compare the computed elevation from step 4 to the assumed elevation of step 1. Embankment overflow combined with pressure flow through the bridge is analyzed as follows: 1) assume an upstream water-surface elevation; 2) compute the resultant embankment overflow; 3) compute the resultant pressure flow; 4) add the computed discharges from steps 2 and 3; and 5) compare the total computed discharge from step 4 to the actual discharge. In both of these procedures, the five steps are repeated until the comparison error in the last step is within an acceptable tolerance. The sign and magnitude of that error governs the selection of a new assumed elevation in the first step of the next iteration.

Multiple Openings

Flow is apportioned among the individual openings (bridge and culverts) and a water-surface profile is computed for each individual opening using a representative strip of the valley. Flow apportionment is based on both flow area of the openings and conveyance distribution of the valley. Valley strips are determined by stagnation (flow division) points, the locations of which are based on relative flow areas of adjacent openings. The flow apportionment and stagnation point concepts are based
on laboratory studies (Davidian and others, 1962) and field verification (Lee, 1976; Colson and Schneider, 1983). Iterations continue until the flow computed for each opening and a conveyance-weighted water-surface elevation at a common upstream cross section do not change significantly on successive iterations.

**Encroachment Analyses**

At present, only options for fixed-limit encroachments and encroachments based on conveyance removal to obtain a target surcharge are available. The latter method is designed to remove equal conveyances from both sides of a cross section, with or without specified constraints. Therefore, the capability exists to satisfy most encroachment analysis requirements. Additional options are planned to provide additional flexibility.

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MILHY: THE ARMY'S WEAPON IN THE FLOOD FORECASTING BATTLE

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Summary

MILHY is a microcomputer-based, single event, hydrologic simulation model developed by the U.S. Army Corps of Engineers Waterways Experiment Station under the Military Hydrology Program, to support and improve the river forecasting capabilities of army terrain teams. MILHY is a menu-driven, user-friendly package which can easily be utilized by personnel without an extensive background in and knowledge of hydraulics and hydrology. Designed for use by the field army in a tactical environment, the model requires a minimum of field data and makes optimum use of topographic maps and aerial photography. Output from the model consists of forecasted discharges, velocities, and water surface profiles.

The program utilizes a modified two parameter gamma distribution for the unit hydrograph theory. Water surface profiles are computed either by a normal depth approximation or, for subcritical flow, the standard step method. Losses for flow through bridges are computed utilizing an energy balance, while a Modified Puls storage indication method is utilized for routing the hydrograph through reservoirs. Stream routing is performed using a variable storage coefficient procedure.

MILHY can be and has been used for nonmilitary purposes. An evaluation of MILHY compared it to HEC-1 (U.S. Army Corps of Engineers, 1981) and PSRM, the Penn State Runoff Model, (Aron et al., 1984) in nonmilitary environments and found that, in comparison to the other models, it performed reasonably well in reproducing observed hydrographs.

Introduction

The terrain, including hydrologic and hydraulic systems, plays a key role in military strategy. A mobile force must be able to cross water obstacles in stride without loss of momentum to minimize the massing of troops and the degrading of force movements. To deal effectively with the terrain—streams and rivers in particular—the field commander must have detailed knowledge of the hydrologic system, including: the gap width, bank heights and slopes, the bottom material, velocity of the stream, and depth of flow. Hydrologic systems are highly dynamic. Stream and river levels rise and fall in response, primarily, to precipitation or lack thereof. Stream conditions observed in advance of an operation may be vastly different from those encountered during the operation. To adequately plan for stream and river crossings,
a commander must have information specific to the crossing area as well as the ability to predict changes resulting from inputs to the hydrologic system during the operation.

The military hydrologist plays a support role for military operations and is concerned with forecasting depth, discharge, and velocity at a point in time given a measured or predicted precipitation. In response to these specific needs, the U.S. Army Waterways Experiment Station (WES) is developing a forecast model to simulate a flood caused by a rainstorm. The model, MILHY, (James, 1983) can be used to forecast the discharge, water velocity, and water surface elevation in a stream during a flood, thus providing an army field commander with the best estimate of stream crossing conditions.

MILHY was developed for users with a limited knowledge of hydraulics and hydrology. The model is designed to limit the number of technical options available to the user and at the same time provide a maximum number of data input options. Technical options were selected to minimize the need for data and to make optimum use of topographic maps and aerial photography. The program can handle a single channel system or a branching system where water surface profiles are to be computed for one or more tributaries to the main channel. Hydrologic computations of the stream flow begin at the uppermost sub-basin and continue downstream. After the hydrologic computations of all the branches have been computed, stream flows for the main channel are computed starting upstream and proceeding downstream. Water surface profile computations start at the lower end of the main channel and continue upstream. The water surface profiles along the branches are computed last, starting at the main channel and continuing upstream.

The program consists of seven data files which must be completed before the computations can begin. The data files are:

1) System file (number and location of branches)
2) Sub-basin data files (sub-basin characteristics)
3) Precipitation files (accumulative rainfall)
4) Routing reach files (start and end of river station of each reach)
5) Reservoir routing files (storage and discharge files)
6) Cross-section files (valley and channel characteristics)
7) Structure files (bridges, culverts, and weirs)
8) Command file (sequence of hydrologic operations)

MILHY is programmed to run on the Microfix (Apple II Plus with 64K storage and CP/M operating system for MBASIC) in both English and metric units. The model will handle a system with up to seven branches, 33 stream routing reaches, 65 cross
sections, 19 reservoirs, 126 sub-areas, six precipitation files and 20 structures. The number of cross sections plus the number of reservoirs and structures cannot exceed 75, and there cannot be more than 50 cross sections on any one branch or channel. Output from the model includes three water surface profiles (peak flow profile and two instantaneous profiles at specified times) and hydrographs (time vs. discharge relationships) at specific crossing sites.

**Model Theory**

The hydrologic portion of the model is an adaptation of the computer program HYMU written by Williams (Williams and Hann, 1973). It is similar to the HEC-l computer program but utilizes a modified two parameter gamma distribution for the unit hydrograph theory. A two parameter gamma distribution can be completely specified by knowing the time to peak and the peak value (Wu, 1963). Williams (1968) modified the gamma distribution so that the required parameters were the time to peak and a recession coefficient that describes, from the point of inflexion, the falling limb of the unit hydrograph.

Rainfall excess is determined by the Soil Conservation Service complex curve number procedure (Soil Conservation Service, 1972), which limits the application of the program to a single event storm. The rainfall excess is convoluted with the unit hydrograph to produce the runoff from any sub-basin. The sub-basin hydrograph can be added or routed to the next downstream location. The model utilizes a variable storage coefficient stream routing procedure developed by Williams (1969), which adjusts the routing coefficients with respect to changes in travel time of the flood wave through fixed reach lengths. The coefficient adjustment is a function of the water surface slope rather than the energy slope, and it is a more accurate routing procedure than most hydrologic routing methods. A storage indication or Modified Puls method is used for reservoir routing.

Water surface profiles are computed by either a normal depth approximation or, for subcritical flow, the standard step method. Losses for flow through bridges are computed using an energy balance. The bridge computations in MILHY are accurate but may not compare easily with results from other computer models.

The hydrograph is routed through reservoirs using a storage indication, Modified Puls method. The outlet flow condition can be simulated with an orifice equation that can be utilized for both inlet and outlet control situations and/or a weir equation for overtopping. An alternative to using hydraulic formulas to compute
outflow is to input a rating table or performance curve for the structure. The rating curve can be generated by any method and then entered as stage versus discharge into the program. Tailwater can be entered as a fixed elevation or computed using a normal depth approximation downstream of the outlet structure.

Comparison of MILHY, HEC-l and PSRM

The three hydrologic models MILHY, HEC-l, and PSRM were applied to five selected watersheds--two in the U.S. and three in the United Kingdom--and the results compared for several storms on each watershed (Aron et. al., 1985). The U.S. watersheds were Brandywine Creek in southeastern Pennsylvania (with a drainage area of 287 square miles) and Fletcher Creek in Tennessee (with a drainage area of 22.13 square miles). The U.K. watersheds were the Wye and Severn catchments in Wales (4.04 and 3.34 square miles respectively) and the Cam watershed in England (75.6 square miles).

The effort needed to prepare input data for the three models was roughly the same, but HEC-l, because of its many options and alternative procedures, made the task of choosing the correct parameters and input sequences somewhat more confusing. The collecting and entering of MILHY input parameters was generally simple with the exception of the cross section detail requirements. Under most conditions, cross sections along drainage paths are not available and must be estimated coarsely.

The two main-frame computer models, HEC-l and PSRM, are, with the aid of modern load modules, extremely fast-running programs. In contrast, MILHY, presently written for an Apple IIe microcomputer, is very slow. For example, the 28-subarea watershed of Brandywine Creek in Pennsylvania was modeled by HEC-l and PSRM in seven to nine seconds, while MILHY took roughly six hours to complete the modeling.

In regard to modeling accuracy, PSRM performed most consistently. HEC-l produced some good simulations, but in other cases it seemed very difficult to obtain a reliable set of calibrated parameters. MILHY performed well on the larger watersheds almost without any calibration but had inherent problems on small areas. These problems were due mostly to the model's use of unit hydrographs which require rainfall input in increments of a few minutes in order not to miss the peak flow. The general slowness of MILHY definitely affected calibration efforts because of the extreme tediousness of running the model with the many combinations of parameters necessary for good calibration.

Model calibration and error analyses centered on the accuracy of reproducing hydrograph peaks and volumes. The researchers realized that the timing of the peaks
was equally important, especially for military hydrology. Since many of the observed hydrographs had multiple peaks, it was difficult to develop a representative measure of the ability to match peak timing. Peak timing was almost always off by one to several hours, and no systematic patterns in these timing errors could be found. In some of the events, a timing mismatch between reported rainfall and runoff was strongly suspected.

Conclusions

The MILHY model was developed to assist terrain analysts in planning river crossing operations. The model has been evaluated on test watersheds and found to give reasonable results. It will predict stream flow conditions due to a single storm event in a forecast period, provided there is sufficient terrain and hydrologic data to construct the model. The use of MILHY could improve the effectiveness of military units in combat situations and, being microcomputer based and having hydrologic and hydraulic capabilities, should be of great interest to the civilian community.

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Wu, I.  
ASSISTING OWNERS OF FLOOD-PRONE STRUCTURES: FLOOD AUDIT PROGRAMS

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USDA, Soil Conservation Service

Phillip A. Renn
USDA, Soil Conservation Service

Alan M. Levere
Connecticut Department of Environmental Protection

Introduction

The USDA, Soil Conservation Service, and the Connecticut Department of Environmental Protection, have implemented a statewide flood warning system and an "ALERT" system in combination with individual flood audits in two flood-prone communities. These efforts are an attempt to reduce flood damages in areas where structural and nonstructural solutions are not appropriate.

The Yantic River watershed, in southeastern Connecticut, has had numerous floods. In response to a request from local communities, the National Weather Service instituted a volunteer network of rainfall observers and provided forecasts of river stages at the local stream gauge. However, flood damage continued because individuals could not relate the flood height at the gauge to their residence or building, and other than trying to keep water out of their structures, they did not know how to respond to warnings (what level to elevate contents, when to move vehicles, etc.). The flood audits, along with the automated precipitation gauge network, provide the needed information and recommended actions to be taken in response to varying levels of flooding.

To reduce flood damages using flood warning, three components are needed: an automated flood warning system, a community emergency action plan, and a property owner action plan. To establish such a system requires the efforts of many federal, state, and local agencies, as well as the support of the floodplain residents. However, when such a program is in place, individuals in the floodplain can be prepared for flooding and can reduce their own flood damages.

Now, in the Yantic River watershed, when homeowners receive the computer generated telephone warning, "The Yantic River will crest at 10:45 this morning at a stage of twelve and a half feet, please begin to implement your flood damage reduction plan," they can start moving contents above flooded elevations, bagging appliances, or sandbagging openings according to their individual plans of action.

The materials included in the appendix to this paper provide background informa-
tion needed to implement a flood audit program—beginning with the information from inundation mapping and proceeding to flood audit techniques.

**Inundation Mapping**

The initial information needed for flood audits are the potential elevations of floods at each individual house or building. Inundation maps and profiles can be developed to show how flood heights at the river gauge relate to an individual building within a floodplain study area. Such maps and profiles contain flood height lines not frequency lines. Three or four levels which represent start of flooding, moderate flooding, and severe flooding can be shown. These lines are not always parallel because of channel restrictions and variations in channel size and roughness, so a difference of two feet at a gauge does not mean a difference of two feet at a house or business.

The maps, in their final form, can be used by a community for evacuation planning and for deployment of community staff. The cost of these maps can be high if they are not included in, or prepared in combination with, another study. In Connecticut, FEMA agreed to include the special map preparation when revising the Flood Insurance Study for a community.

**Flood Audit Techniques**

**Audit Form**

The inundation map information and a first visit with an individual building owner provide the interviewer with the physical data needed to prepare an action plan for that individual. Figures 1 and 2 in the appendix show the data needed.

**Other Factors Evaluated**

An evaluation of soils is important for buildings with basements which are susceptible to subsurface flooding. The permeability range of the soil needs to be known if pumping is recommended. Moreover, the water pressure in the soil will affect the pressure on a building during a flood.

For the Connecticut effort, 18 inches was used as a safe height for water against any part of a building. The decisions made and factors considered before deciding on 18 inches were: 1) structural stability of each individual home was not examined; 2) the soils were very permeable; and 3) the flood waters remained high for more than a few minutes.
Audit Technique Overview

Three types of floodproofing can be recommended: 1) permanent techniques which require little operation, 2) stand-by or temporary techniques which require preparation and operational input, and 3) emergency techniques.

Permanent Techniques. Constructing flood walls, bricking windows, raising sills, and elevating utilities are expensive options but will keep an area dry. Figure 3 in the appendix shows some of these techniques used for a residential dwelling. In Connecticut, fact sheets on such things as flood wall construction and appliance elevation proved to be an effective way of providing information so that landowners could understand the possible solutions to flooding problems (an example of a fact sheet is included as Figure 4 in the appendix).

Stand-by Techniques. Stand-by floodproofing measures must be implemented by a resident at the necessary time. Such measures include the construction of flood shields, the bagging of appliances, and the installation of relief drains and sumps. This information can also be easily conveyed to homeowners by simple fact sheets.

In addition to these techniques, the installation of quick electrical disconnects instead of wire/screw-in contacts, and wing nuts instead of regular nuts to hold furnace burners in place will save homeowners time when preparing for a flood.

Emergency Floodproofing Measures. Emergency floodproofing measures can also be easily communicated in fact sheets. They include sandbagging, the use of water-tolerant materials, and the development and implementation of an evacuation plan.

An example of a completed flood audit for a severely flooded residence is included as Figure 5 in the appendix.

Conclusion

Individual flood audits provide another option to reduce flood damages. When individuals receive a warning and implement an action plan, flood damage reduction benefits are fully realized both by the individuals and the community in general. Because numerous agencies and individuals are involved in instituting such a system, an indirect benefit of the flood audit program is an increased awareness of flood problems within the community.
**ASSISTING OWNERS OF FLOOD-PRONE STRUCTURES**

### APPENDIX

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<th>Address</th>
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<th>Contact</th>
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<td>0%</td>
<td>0%</td>
<td>3%</td>
<td>2%</td>
<td>1%</td>
<td>0%</td>
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<td>4.5&quot;</td>
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<td>24.0&quot;</td>
<td>39.0&quot;</td>
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<td>3/4</td>
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<th>3.0&quot;</th>
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<th>5.0&quot;</th>
<th>6.0&quot;</th>
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<td>2/2</td>
<td>3/4</td>
<td>4/7</td>
<td>5/10</td>
<td>7/13</td>
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</table>

|---------------|--------------|-----------------|-------------------|

**STRUCTURE**
- House - Building - ______ stories - ______ car garage - shed - 

**FOUNDATION**
- Stone - Conc - Conc - Conc Blank - brick - Conc slab - 

**WALLS**
- Conc - Conc Blank - 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 - ) - 

**FURNACE**
- 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 - Ground - Surface - Storm sewer - Sanitary sewer - DISCHARGE 

Any flood related problems?

**FLOOD PREVENTION MEASURES**
- Sump pump - Sandbag - Shield - Sealant - 

**ENTHUSIASM**
- (-) (-/-) (+/-) (+) 

Plate ______

I.D. No. ______

NAME ____________________________ c/r u/s-d/s of ________

**Figure 1**

Interview Sheet Used for Initial Interview
<table>
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<th>X</th>
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<td>2. 6/82 Flood Depth</td>
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<td>4. Bas Ent</td>
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<td>5. Bas Mt Wind</td>
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<td>6. H2O Line/Meter</td>
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<td>7. H2O Pump</td>
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<td>8. H2O Heat</td>
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<td>9. Gas Line/Meter</td>
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<td>10. Elec Line/Meter</td>
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<td>11. Fuse/Cir Brk</td>
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<td>12. Tel A Line</td>
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<td>13. Septage Line</td>
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<td>14. Toilet</td>
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<td>15. Sink/Tub/Sl</td>
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<td>16. Furnace &amp; Burner</td>
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<td>17. Fuel Tank/Line</td>
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<td>18. Tank Intake/Vent</td>
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<td>19. Air Conditioner</td>
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<td>20. De/Humidifier</td>
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<td>21. Wash/Dry (g) (e)</td>
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<td>22. Refrig/Freeze</td>
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<td>23. Stove/Oven</td>
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<td>24. TV/Stereo</td>
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<td>25. Furniture</td>
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<td>26. Records</td>
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<td>27. Tools/Machinery</td>
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<td>28. Shelves</td>
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<td>29. Sump Pump</td>
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<td>30. (Other)</td>
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Figure 2
Initial Interview Sheet--Page Two
Figure 3
Examples of Permanent Floodproofing Techniques for a Residence
BAGGING APPLIANCES

For large appliances, seal openings with wide tape, tie shut, and anchor the appliances to prevent floating and damage to the appliance and surroundings. Anchorage can be attained by placing weight on the appliance (sandbags) or attaching the top of the bag to a counterweight from the ceiling to keep the appliance floating upright. If you are not able to anchor these appliances, leave them open to allow water into the interior to prevent floating. Top loading dishwashers and clothes washers should first be filled and weighted down with clean water to prevent floating. Freezers can be weighted down with food, including canned food and other heavy items, sealed and anchored. The plastic bag should be placed around the appliance on a permanent basis ready for use. Place a rubber or styrofoam pad under the plastic bag and under the appliance between the bag and appliance bottom to protect the bag from damage in normal use. See diagrams below.

<table>
<thead>
<tr>
<th>Flood Depth in Room (Feet)</th>
<th>Washer Weight (lbs.)</th>
<th>Dryer Weight (lbs.)</th>
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<tr>
<td>0.35</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>0.6</td>
<td>none</td>
<td>90</td>
</tr>
<tr>
<td>1.0</td>
<td>130</td>
<td>220</td>
</tr>
<tr>
<td>2.0</td>
<td>460</td>
<td>570</td>
</tr>
<tr>
<td>3.0</td>
<td>790</td>
<td>920</td>
</tr>
<tr>
<td>4.0 and greater</td>
<td>970</td>
<td>1130</td>
</tr>
</tbody>
</table>

Typical weight 200 lbs. 130 lbs.

Typical size 29"x26"x43" h 29"x28"x43" h

Buoyancy Force per 1.0 ft. of water depth

330 lbs. 350 lbs.

Disconnect heavy, immovable appliances. When the electrical service is being returned to your home after a flood, all appliances must be disconnected to facilitate determining whether any problems exist in the electrical distribution system. Remove electrical motors from immovable appliances, bag, and take to a higher level above the flood depth.

Figure 4
Sample Fact Sheet
NAME ____________________________ Structure No. 236

ADDRESS ____________________________ Telephone No. ________

Alternate Tel. ________

I. Floodwaters first enter your basement at Flood Warning Level 9½.

II. Relocate vehicles, trailers, etc., to high and dry ground at Flood Warning Level 13½ driving the following route: east on Sturtevant.

III. Absolutely EVACUATE everyone from the building at Flood Warning Level 16 carefully walking the following route: across the Street to high ground, then east to Sturtevant to West Town.

IV. SPECIFIC FLOOD RELATED INFORMATION FOR YOUR LOCATION

<table>
<thead>
<tr>
<th>Flood Warning Level (in feet)</th>
<th>10</th>
<th>12</th>
<th>14</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability during any one year</td>
<td>50%</td>
<td>10%</td>
<td>3.3%</td>
<td>1.0%</td>
</tr>
<tr>
<td>Inches of rain in a 24-hour period</td>
<td>3.4&quot;</td>
<td>5.0</td>
<td>5.9</td>
<td>7.1</td>
</tr>
<tr>
<td>Floodwater Depth for:</td>
<td>XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>basement¹</td>
<td>7&quot;</td>
<td>47&quot;</td>
<td>71&quot;</td>
<td>full</td>
</tr>
<tr>
<td>first floor</td>
<td>0</td>
<td>0</td>
<td>(-9&quot;)</td>
<td>22&quot;</td>
</tr>
<tr>
<td>other: road</td>
<td>0</td>
<td>0</td>
<td>12&quot;</td>
<td>43&quot;</td>
</tr>
</tbody>
</table>

Notes:

²Remember that your evacuation route may become flooded before your building. Most cars can be safely driven through six (6) inches of water covering the road; one (1) foot for most light duty trucks. All people and pets should also EVACUATE at this time, except for those individuals necessary to implement remaining flood damage reduction actions.

³Based on low hazard evacuation conditions by typical adults on foot.

Figure 5
Example of a Completed Flood Audit for a Severely Flooded Residence
V. RECOMMENDATIONS TO CONSIDER TAKING WELL IN ADVANCE OF THE NEXT POTENTIAL FLOOD

- Purchase or continue flood insurance coverage.
- Obtain special plastic bags for all your appliance, motor, etc., needs which protect such hard to relocate items once items are bagged. Position bags and ties for quick and easy use.
- Obtain and properly install a sump pump with at least a 1½" diameter discharge.
- Obtain a gas generator capable of operating your sump pump(s) during electrical service interruptions. You may also want to consider additional wattage capability for other electrical needs.
- Design and construct a new utility room at least 24 inches above first floor and relocate utilities.
- Locate nearby and readily available source of sandbag materials (bags, sand and plastic); become familiar with sandbagging process.
- Obtain correct size rubber check valves for installation in waste and/or drain lines to prevent back-ups.
- Raise fuse or circuit breaker box to at least 24 inches above first floor.
- Relocate items with electronic devices (computers, security systems, numerical control devices, instruments, switches, etc.) to keep such electronic devices at least 24 inches above first floor.
- Relocate items with motors and transformers to keep motors and transformers at least 24 inches above first floor.
- Modify items with electronic devices, motors, transformers, and heating system burners to allow for quick disconnection and removal.
- Properly anchor fuel tank(s) and other buoyant objects which may cause damage.
- Raise fuel tank intake(s) and vent(s) to at least 24 inches above first floor.
### Basement Items
- 5 pU1tp1
- Furnace and Burner
- Water heater
- Machinery/Tools
- Stored Foods
- Fuel tank
- Fuse box or circuit breaker
- Other items of value
- Dryer and Freezer
- Door to outside

### Structure

**Actions to take for the forecasted flood warning level**

<table>
<thead>
<tr>
<th>Level</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 to 10 ft</td>
<td>Bring burners to first floor. Bring furnace and Burner, and remove before and dry circuit breaker. Store all electronics, and remove circuit breaker, and dry circuit breaker.</td>
</tr>
<tr>
<td>11 to 12 ft</td>
<td>Prepare to turn off onsite fuel supply at pump.</td>
</tr>
<tr>
<td>13 to 14 ft</td>
<td>Turn off power.</td>
</tr>
<tr>
<td>15 to 16 ft</td>
<td>Be prepared to turn off power.</td>
</tr>
</tbody>
</table>

**Because subsurface water is causing critical stress on basement floor and foundation, high hazard exists for structural damage and flooding.**

If you have a generator, check its operation and fuel supply for use during electrical service interruption.

**Figure 5—continued**
### STRUCTURE NO. 236

**FIRST FLOOR**

<table>
<thead>
<tr>
<th>Location</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Floor</td>
<td>No action.</td>
</tr>
<tr>
<td>2nd Floor</td>
<td>Move to second floor or raise 2.5 feet if higher.</td>
</tr>
<tr>
<td>3rd Floor</td>
<td>No action.</td>
</tr>
</tbody>
</table>

**EXPRESSIONS**

- **Vehicular evacuation** once road is covered with at least 16 inches (approximately the 15 foot flood warning).
- **People and pets** higher elevation once road is covered with at least 15 inches of water (approximately the 15 foot flood warning level).
STRUCTURE

LOCATION: OUTSIDE

ACTIONS TO TAKE FOR THE FORECASTED FLOOD WARNING LEVEL

<table>
<thead>
<tr>
<th>Levels of water</th>
<th>Actions to take</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than ankle</td>
<td>Leave property.</td>
</tr>
<tr>
<td>Ankle to waist</td>
<td>Leave property.</td>
</tr>
<tr>
<td>Waist to chest</td>
<td>Leave property.</td>
</tr>
<tr>
<td>Chest to under</td>
<td>Leave property.</td>
</tr>
<tr>
<td>Shoulder</td>
<td>Leave property.</td>
</tr>
<tr>
<td>Neck</td>
<td>Leave property.</td>
</tr>
<tr>
<td>Head</td>
<td>Leave property.</td>
</tr>
<tr>
<td>Float</td>
<td>Leave property.</td>
</tr>
</tbody>
</table>

Note: On typical car, light duty truck can safely go through 1 foot of water.

Action to take: Leave property. Locates No. 275

Figure 5--continued
A DATA BASE MANAGEMENT APPROACH TO FLOOD DAMAGE REDUCTION STUDIES

Stephen W. Shawcross
IBI Group

Augusto R.V. Ribeiro
ECOS Engineering Services Ltd.

Introduction

Past damage reduction studies have employed a variety of techniques to estimate flood damages. In the more sophisticated of these studies, commercial and residential structures have been inventoried and classified with potential damages assessed through the use of either existing or specifically created stage-damage curves, which depict the relationship between inside water level and the amount of damage per structure (Figures 1 and 2). These flood damage estimates are subsequently used in the evaluation of remedial alternatives and in the formulation of floodplain management plans.

Traditionally, damage reduction studies have relied almost exclusively on the hand calculation of damage results—a long process for larger centers and quite complicated if input variables, such as water levels, are modified. Studies of this nature are time consuming, costly, and prone to error, given the thousands of calculations that are ultimately required. Additionally, suggested remedial alternatives tend to be global rather than site-specific, with resultant inefficiencies and
potential oversimplification of damage reduction strategies.

Finally, because these types of studies do not easily lend themselves to updating, they tend to be "one shot" efforts, which is a particularly serious drawback when one considers the nature of floodplain management:

- Flooding is a long-term problem;
- The floodplain is dynamic, and a static set of data will not reflect land use changes, or changes to other variables (hydrology, channel morphology, etc.) over time; and
- The implementation of remedial measures is a long-term process and these measures are most often staged over an extended period of time.

All of these factors necessitate continual updating and re-evaluation of floodplain management strategies.

Obviously, new techniques are required if comprehensive and effective floodplain management is to be realized. With the advent and dissemination of microcomputers, a new technology now exists that water resource agencies and others having jurisdiction over floodplains can use to deal more effectively with flood hazards. The remainder of this paper describes a flood damage data base management system that has been developed by the authors over the past five years to facilitate more thorough analysis of flood data and provide floodplain managers with a powerful tool for decision making.

Overview of Flood Damage Data Base Management System

Essentially, the flood damage data base management system is a sophisticated computer program which allows for the storage and manipulation of flood damage data. It has the capability of estimating total and average annual damages per individual structure, relative to a series of flood levels and frequencies (Figure 3). Enhancements include tabulations of various unit types by community, reach, and flood zone (floodway, flood fringe, etc.). Also, the program/system computes damages both with and without sewer backup. Another important element of the overall system is the fact that the computer data base is cross-referenced to flood line mapping via a sequential unit number, which identifies individual buildings within the floodplain (Figure 4). Thus, a floodplain manager can locate specific damage data on plans and thereby isolate problem areas and specific structures. This permits an evaluation of remedial alternatives on a reach-by-reach basis, rather than a more global analysis based on damage estimates for the entire study area.
Applications

The program facilitates the ready access and manipulation of flood damage data and specifically can be used to perform the following functions:

- **Computation of damages for different flood elevations.** Structural and content damages are computed for individual structures for a series of flood elevations, i.e., 1:10, 1:25, 1:50, etc. These are aggregated by subreach, reach, zone, community, and study area. Commercial and residential flood damages are computed separately.

- **Rapid updating of data base.** This is an essential component of any dynamic floodplain management plan. Any changes in conditions within the floodplain (i.e., additional development or demolition) are entered and damages recalculated.

- **Information Retrieval.** Simply formatted, yet comprehensive, spreadsheets are provided for various types of data and report summaries.

- **Screening and manipulation of data for the evaluation of remedial alternatives.** This function allows for the removal of records from the file and the recomputation of damages, based on various levels of protection provided by individual or composite solutions. Detailed benefit/cost analyses can then
be undertaken to determine a plan to deliver the optimum level of protection.

- **Rapid comparison of results using different damage functions.** Various stage-damage curves can be employed to compute damages with sensitivity analyses conducted on the results.

- **Risk analyses.** Several subroutines have been created that allow the disaggregation of risk-related data, i.e., depth of flooding per structure, population within floodplain, etc.

- **Planning studies.** Subroutines have been added for the tabulation of various unit types, number of commercial structures, and associated square footage to allow for the computation of floodproofing and relocation cost estimates.

All of these functions and analyses are integral to the formulation of comprehensive floodplain management strategies.

**Technical Description of the Computer System**

The system is driven entirely by "menu" (Figure 5). The master menu directs the user to five main modules, three of which are repeated to account for differences between residential and commercial data. When the system is initiated, the master menu requests a selection of one of nine options: two input/output options, two damage calculation options, two print options—one for residential and one for commercial data—and two additional options—one to create depth-damage curves and one to create flood elevation files. The final option is to exit the program.

The input option is used to create the data base file which includes the address, house type, unit classification, main floor elevation, etc. of structures. The input program allows a person to create and modify any item on record by means of an edit module. The next two options are used to create the depth-damage file and flood elevations by zone and reach for contents and structural damages for residential and commercial/industrial units. The data base, damage, and elevation files are used in the damage calculation option which computes total damages for various frequencies and flood elevations (Figure 6). This option also integrates the total damage values to compute average annual damages for each structure and total average annual damages for the community or zone on the data base file, finally storing the results on an output file. The print option accesses the input and output files and prints their contents for review (Figures 7 and 8). The accompanying flow chart (Figure 5) illustrates conceptually the functional relationships as well as the various inputs and outputs.
**Figure 5**
Computer Program System

**Figure 6**
The Damage Calculation Option
Computes Total and Average Annual Damages

<table>
<thead>
<tr>
<th>Zone Reach Number</th>
<th>Address</th>
<th>Unit Grace Elev</th>
<th>Basement Garage Elev</th>
<th>Outdoor Class Elev</th>
<th>Flood Elev</th>
<th>Page 5 Elev</th>
<th>Data Set File</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 21</td>
<td>366 615</td>
<td>29 AVE NW</td>
<td>1052.1</td>
<td>0.2</td>
<td>Y Y N</td>
<td>N Aw</td>
<td>EPIK.18G</td>
</tr>
<tr>
<td>0 21</td>
<td>361 418</td>
<td>29 AVE NW</td>
<td>1052.1</td>
<td>0.2</td>
<td>Y Y N</td>
<td>N Aw</td>
<td>EPIK.18G</td>
</tr>
<tr>
<td>0 21</td>
<td>362 2993</td>
<td>ELBOW DRIVE</td>
<td>1052.0</td>
<td>0.2</td>
<td>Y Y N</td>
<td>N Aw</td>
<td>EPIK.18G</td>
</tr>
<tr>
<td>0 21</td>
<td>362 2997</td>
<td>ELBOW DRIVE</td>
<td>1052.1</td>
<td>0.2</td>
<td>Y Y N</td>
<td>N Aw</td>
<td>EPIK.18G</td>
</tr>
</tbody>
</table>

**Figure 7**
Data Base Input

**Figure 8**
Data Base Output
Hardware and Enhancements

This particular system has been developed to operate on an IBM-PC and other MS-DOS compatible, 16-bit microcomputers with a minimum of 128K RAM and two disk drives. Currently, the program is being enhanced so that it will interface with the AUTOCAD 2+2 attribute function, allowing the user to combine the data base with digital floodplain mapping. As well, the system generates ASCII files for interchange with other programs, such as dBASE III, LOTUS/SYMPHONY, etc.

Information Requirements

The basic information requirements for this type of system are germane to any flood damage reduction exercise and include: 1) accurate contour mapping at no less than a 1:5,000 scale, or alternatively, a level loop survey of structures within the floodplain; 2) flood elevations for various flood frequencies (these are usually derived from HEC-2 back water profiles); and 3) stage-damage curves (several sets of curves are available, including the widely used FIA curves, along with site-specific curves, if required).

Conclusions

As discussed, this particular system has numerous applications, and promotes a preventive approach to floodplain management—an approach in which risk and damage potential are assessed prior to an actual flood event and the appropriate remedial measures implemented. This approach is certainly commensurate with the apparent redirection of floodplain management within both the United States and Canada. The development and evolution of this and other similar data base systems will considerably enhance the effective management of floodplains in the future.
AN ECONOMIC AND HISTORICAL PERSPECTIVE OF FLOOD DAMAGE:
THE VIABILITY OF STRUCTURAL SOLUTIONS

Douglas Woolley
Radford University

Attempts to reduce potential flood damage by constructing large works for protection have come under criticism by many persons on many occasions. Quite apart from environmental groups (who might be expected to prefer nonstructural solutions to flood problems), another interested group has challenged such construction on a purely pragmatic basis. They believe that in spite of our best intentions to control nature, statistics indicate that flood damage from large events, as measured in dollar terms, continues to rise. For example, the great floods of 1937 which affected many areas of the United States—particularly the Ohio and Mississippi valleys—produced about $440 million in damage and brought about the construction of many of our major civil works projects. Yet in spite of efforts to eliminate flood damage, the events of 1983 produced nearly ten times as much damage (in monetary terms). Indeed, the sense of security engendered by such things as massive levees and dams has led people to build in areas otherwise susceptible to flood damage and thus has created an even greater risk of disaster in the event of abnormally large events in the future. As Kenneth Boulding says,

After spending four billion dollars on flood control in this country, we are more in danger of major disasters than before, because we have treated floods as a problem of the river, not as a problem of people, and we have attempted to deal with the problem in engineering terms instead of in terms of social institutions such as zoning and architectural design.

Such criticism may not be appropriate. Humans have always been concerned with assessing risks and with protecting property from damage caused by natural phenomena. The decision making process preceding construction involves a complicated calculus involving such things as knowledge of past and possible future events, costs of protection, benefits derived from the use of susceptible property, and the likelihood of cooperation when there are extensive externalities associated with potential solutions.

Although there is little doubt that individual plans may involve both inconsistencies and inefficiencies, the collective effort of the nation, particularly when viewed over a period of time, is more difficult to assess. One must ask whether an increase in the dollar amount of damage actually means that the projects that have been built have not worked. I would say no; simply because there are problems with individual projects, one should not condemn entire programs. Also, over an extended
period of time, new variables may have affected the measured amount of flood damage.

There are at least four major factors that should be considered when evaluating the success of flood damage control programs: inflation, population, wealth, and social attitude toward risk.

**Inflation**
The general increase in prices has, by itself, caused damages measured in current dollar terms to rise significantly. There has been a six-fold increase in prices since 1930, and between 1967 and 1986 prices tripled. At a minimum, current dollar statistics must be deflated to get an accurate picture.

**Population**
The population of the United States has nearly doubled since 1930. This growth has increased pressure to develop previously unused land. Also, since much risk-taking is done on an individual basis, it could be argued that, on a purely proportional basis, total damage could be expected to double as population doubles.

**Wealth**
As the economy grows and the society accumulates buildings (residential, commercial, and industrial), equipment, and personal property, the relative productivity of other basic resources i.e., land and labor, also increases. The value of all land grows—including that which is susceptible to flood damage. In short, the temptation to put that land to use tends to become greater as the costs of letting it remain idle rise.

**Social Attitude Toward Risk**
Although the effect of the three factors mentioned above can be predicted with some degree of certainty, the social attitude toward risk is more debatable. Much has been said but little has been agreed upon with regard to whether wealthy communities become more or less averse to risk as time passes. The entire matter is further complicated by the fact that measurement of risk can be undertaken on an individual or on a collective basis. The act of constructing on a floodplain involves an individual decision to place wealth at risk, but the construction of a large levee or dam represents a collective decision to avoid risk; yet these two acts are interdependent. The amount of damage that occurs annually is linked to this social attitude and its relationship to individual and collective response.

**The Model**
Accordingly, a simplified expression of the causal variables contributing to the
amount of flood damage as measured in current dollars (i.e., not adjusted for inflation) could be given as follows:

\[ D = f(P,N,W,A) \]  

Where \( P \) is a price index for deflating national product, \( W \) is a measure of wealth, \( N \) is population, and \( A \) is the social attitude toward risk. Ideally a statistical analysis of flood damage would specify values for all of the above mentioned variables. This analysis however, is simpler. It is assumed that the current measure of gross national product (GNP) is dependent on and thus reflective of the variables \( P \), \( N \), and \( W \), thus substituting:

\[ D = g(GNP,A) \]  

and concluding:

\[ \frac{D}{GNP} = h(A) \]  

or:

\[ \frac{D}{GNP} \rightarrow A \]

In summary, by dividing by a current measure of GNP, one can, to a degree, neutralize the expected impact of inflation and the growth of population and wealth on measures of flood damage. The resulting fraction or statistic when plotted should provide a more meaningful measure of relative damage over time. In fact, one might conclude two things from the data. First, and obviously, the data will suggest whether flood damage is becoming more or less of a problem over time. (This incidentally, is a related yet separate question from the relative efficacy of flood control projects). Second, the data points when regressed, may suggest something about the attitude toward risk of the society as it becomes more affluent.

**The Results**

Gross National Product and annual flood damage data are available for the U.S. since 1929. The measures of damage were divided by GNP to give a percentage and plotted in Figure 1. Although the graph is compressed, some of the major historical floods can be seen as peaks. The highest peak corresponds to the great flood of 1937
FLOOD DAMAGE--AN ECONOMIC AND HISTORICAL PERSPECTIVE

Figure 1
Relative Flood Damage, 1929-1983

N = 55

Y 823E-6 926E-6 Y=-650E-8*X+ .00119 862E-9
for which damage amounted to .0049% of GNP. Comparing this to 1983's figure of .0012% we can see that although the amount of damage done during the later flood may appear significant, it was, in a relative sense, only one quarter as bad. The peaks of 1951, 1955, and 1972 can be attributed respectively to the Missouri River flood, and hurricanes Diane and Agnes.

A regression line for the data was plotted, and, as can be seen, has a negative slope. Again, however, because of the compressed nature of the graph the slope probably appears more significant than it may really be. Particularly when we take away the peak for the floods of the 1930s, one is struck by the fact that relative damage has remained, on the average, fairly constant through time.

**Conclusion**

Dividing annual current dollar estimates of flood damage by GNP provides a useful device for evaluating the success of flood management efforts made by the society. By the nature of the statistic the distinctions between structural, nonstructural, private, and public flood control and flood avoidance are obscured. But if one concludes that in a democratic and pluralistic society many different viewpoints and needs must come to bear on social solutions, then the fact that relative damage has remained fairly constant through time must be significant. I am not surprised by this outcome. It seems logical that "risk-taking" when applied to millions of individuals over 50 years would be a constant phenomenon. Thus structural solutions are an integral part of the collective logic that, in light of the facts, should not be singled out for special criticism.

**References**

Boulding, Kenneth E.  

Hoyt, W. and W. Langbein  

U.S. Department of Commerce  
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SUMMARY OF A COURSE IN MAPPING PROCESSES

Bernard W. Solomon, Michael W. Dobson, and Albert V. Romano
Greenhorne & O'Mara, Inc.

Introduction to Photogrammetry

This portion of the course provided an overview of photogrammetry. The presentation included a discussion of the five major disciplines within the science of photogrammetry: aerial photography, photo lab services, ground control survey services, stereo viewing and plotting, and final drafting or digital graphics. The interaction between the disciplines was discussed, and the equipment associated with each discipline was identified. The history of photogrammetry was covered, including Aristotle's and da Vinci's experiments with photography; aerial mapping in the Franco-Prussian War, when the German army was the first to create an aerial mapping corps; and the first major engineering use of aerial mapping by the Tennessee Valley Authority. The future of photogrammetry was also discussed including its industrial and medical uses and its application to automated guidance systems that require terrain models of the earth and other planets. A film produced by the Wild Instrument Company was used to illustrate basic photogrammetric concepts and processes.

A discussion of the equipment and procedures associated with aerial photography covered the latest innovations in aerial cameras, the geometry and effects of various lens focal lengths, calibration reports, and the various types of film used in both aerial mapping and remote sensing.

The subject of ground control was also discussed in depth. Covered in this discussion were the differences between tied and untied control, monumented control, and the conventional and analytical procedures of obtaining control for photogrammetric use. The evolution and uses of various types of stereo plotting equipment were also discussed. This equipment includes anaglyphic, analog, and analytical plotters. The strengths and weaknesses of each type of plotter were discussed in relation to the end map product, and the graphic output capabilities of each plotter were reviewed. These capabilities include pencil and ink drafting, scribe drafting, and interactive graphics.

The relationship of aerial photography to map scale, contour interval, and accuracy was then explored in depth. The limitations imposed on aerial photography by seasons, ground cover, weather, and flight restrictions were also discussed. Finally, basic cost considerations for a photogrammetric project were outlined, and the effects of project size on unit cost were evaluated.
**Introduction to Digital Cartography**

This section of the course was an overview of digital cartography. The presentation included a discussion of the methods and techniques of automated mapping. These include the selection of the mapping objective, data collection/compilation, coding/symbolization, and rendering and reproduction. Although automation of the mapping process does not require radical changes in established cartographic theory or practice, it will systematize many mapping practices now understood only intuitively and facilitate the production of spatial data. Moreover, the structuring of cartographic information for digital processing may require that more attention be paid to the nuances of cartographic theory than is now paid in manual production.

The first stage of the mapping process is the selection of the mapping objective; the nature and content of the map message, the type of map capable of communicating that message, and the capabilities, benefits, and limitations of automated processes must be considered.

The second stage of the mapping process—data collection/compilation—was discussed in depth. During this stage, information related to the geographic and thematic portions of the map must be gathered, manipulated, structured, and put into a format that is consistent with the objectives of the map. In the discussion of "data capture," which is the digital correlate of data collection/compilation, the differences between image data and attribute data were explained. Image data are coordinates that identify geographic entities. Attribute data are nonlocational data that define the characteristics or features associated with the geographic entities. Image and attribute data must be geocoded in a form compatible with cartographic and machine processes, and it is important to preserve the desired spatial properties of geographic entities within the environment of computer storage.

The coding, or symbolization, of the compiled data—the third stage in the mapping process—is the essence of digital cartography, and this process was also discussed in depth. The spatial and nonspatial attributes of geographic entities were reviewed: spatial attributes pertain to the locations and dimensions of geographic entities and are punctiform, linear, areal, or volumetric. Nonspatial attributes consist of thematic or temporal attributes or characteristics relating to the reliability, resolution, or significance of the information to be portrayed. Nonspatial attributes are classified according to their scale of measurement (nominal, ordinal, or interval/ratio). The representation of spatial and nonspatial properties with map symbolism was also discussed. Because this symbolism has both
spatial and nonspatial properties, a distinction must be made between spatial information and symbol representation on the map. The four steps in the conversion of data to map symbolism are: 1) information manipulation, 2) symbol/map space assignment, 3) selection of the nonspatial component of symbolism, and 4) creation of the physical symbol.

The discussion of the final stage of the process—rendering and reproduction—centered on the conversion of structured digital data into a physical map. The processes involved in the conversion are image selection, image creation, and interactive editing. These processes are common to computer graphics in general and involve the creation of a display file and the subsequent representation of the file by a display device. The interrelationship between the structure of the display file and the display device was also discussed.

In summary, digital cartography has permitted a more analytical and consistent approach to the implementation of cartographic techniques, has introduced new potentials for map products and for the design and construction of maps, and has made possible non-map cartography, in which cartometric problems may be resolved directly from the digital data.
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OUTLINE FOR A COURSE IN FLOODPLAIN MANAGEMENT THROUGH LAND USE REGULATION

Dwight H. Merriam and John D. Pagini
Robinson & Cole

I. INTRODUCTION
A. Scope of Short Course
   1. Legal foundations
   2. Range of floodplain management techniques through land use regulation
   3. Factors to consider in drafting a legally defensible floodplain ordinance

II. LEGAL FOUNDATION OF FLOODPLAIN REGULATION
A. Definition of "Floodplain"
   1. Inland riverine flooding
   2. Tidal flooding
   3. 100-year flood
   4. Range of flooding: Annual flood to Standard Project Flood

B. Purposes of Floodplain Regulation
   1. Human safety
   2. Health
   3. Protection of personal property
   4. Protection of wildlife habitat
   5. Water quality protection
   6. Erosion/sedimentation control
   7. Enhanced recreational use
   8. Agricultural preservation

C. Historic Overview of Floodplain Regulation
   1. River and Harbors Appropriation Act (1899)--jurisdiction given to the Army Corps of Engineers ("COE") over navigable waters
   2. "Navigational servitude"--public trust doctrine
   3. Fish and Wildlife Coordination Act of 1958--federal construction permit programs with Fish and Wildlife Service (COE consideration of environmental issues)
   4. Federal interest in flood control limited to more than a century of involvement in structural programs (construction of dams, dikes, rivers, and channels)--the pattern of flood damage was not being checked, despite substantial federal investment
   5. Some state and local governments regulated floodplains before the NFIP--independent of federal controls (e.g., Connecticut channel encroachment
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lines, Conn. Gen. Stat. #22a-342, et. seq.).

6. National Flood Insurance Program (NFIP) established under the National Flood Insurance Act of 1968--an attempt to shift the cost of floodplain losses to floodplain users:

A purpose of the act was to encourage state and local governments to make appropriate land use adjustments to constrict the development of land exposed to flood damage and minimize damage caused by flood losses and to guide development of proposed future construction, where practicable, away from locations threatened by flood hazards.


7. The Coastal Zone Management Act of 1972 (CZMA)--established coastal zone management programs nationwide to protect coastal storm hazard areas. States chose to regulate coastal areas in a variety of ways (delegation of review authority to municipalities; networking of various laws [i.e., floodplain zoning, coastal and inland wetland laws]).

8. The NFIP has been the major impetus for increased floodplain management through land-use regulation.

D. Legal Issues

1. Police power--land use and zoning regulations as constitutional exercise of the police power (Euclid v. Ambler Realty Co., 272 U.S. 365 [1926])

2. Enabling authority must be adequate--due process requirements dictate that floodplain regulations can be adopted only if the governmental unit is authorized to adopt such regulations by an enabling statute or home rule powers.

a) Floodplain regulations must be consistent with the delegation of authority. Turnpike Realty Company Inc. v. Town of Dedham, 284 N.E.2d at 896:

We first state our view that the last sentence of G.L. c. 40A, §2, does not in any way limit the authority of a municipality to enact a flood plain zoning by-law. Even before the last sentence became part of the enabling act, we believe that a municipality could validly have enacted a flood plain zoning by-law under the general grant of authority in G.L. c. 40A, §2 (to promote the "health, safety, convenience, morals or welfare"), and for the reasons set forth in G.L. c. 40A, §3 ("to secure safety from fire, panic and other dangers"). See Dunham, Flood Control Via the Police Power, 107 U. of Pa.L. Rev. 1098, 1118-1121. Although it might be argued that such authority to enact flood plain zoning could not be implied before the insertion of the last sentence of G.L. c. 40A §2, and that we must therefore regard the objective of such flood plain zoning as limited to the protection of
"occupants" of residences on land subject to flooding, we think it "just as logical to regard . . . [the last sentence of G.L. c. 40A, §2] as a clarification of an ambiguity and a legislative interpreta­tion of the original act." See Fitz-Inn Auto Parks, Inc. v. Commissioner of Labor & Indus. 350 Mass. 39, 42, 213 N.E.2d 245. We believe that the test governing the validity of a flood plain zoning by-law or ordinance is the same as that governing any other zoning by-law or ordinance. "The test is whether there has been shown any substantial relation between the amendment and the furtherance of any of the general objects of the enabling act." Caires v. Building Commr. of Hingham, 323 Mass. 589, 593, 83 N.E.2d 550. Lamarre v. Commissioner of Pub. Works of Fall River, 324 Mass. 542, 545, 87 N.E.2d 211. The promotion of the public welfare, as that term is fairly broadly construed, is chief among the purposes of the enabling statute." Lanner v. Board of Appeal of Tewksbury, 348 Mass. 220, 228, 202 N.E.2d 777, 784.

3. Procedural due process--regulations must be adopted in close compliance with statutory procedures. A.H. Smith Sand and Gravel Company v. Department of National Resources, 313 A.2d at 827, 828 (Md.App. 1974): We are not obligated at this time to determine what should or should not be taken into consideration in planning. The issue here is a juris­dictional one insofar as the Department is concerned. Its jurisdiction extends to the floodplain on the basis of a 50-year flood frequency. If the floodplain were to be determined upon the basis of "future development," then inevitably the questions that would arise would include as of what date the future development should be determined and what the future development would be. There is some indication here that the culvert installed under Greenbelt Road by the State actually restricts the flow of water and, therefore, raises the potential flood level. If one were to determine the floodplain upon the basis of future development, then certainly a question would arise as to whether such future development would provide for pulling the stopper out of the bottle, so to speak, by enlarging that culvert. We see nothing in this statute indicating an intent on the part of the General Assembly that a determination of the floodplain should be on the basis of development at some time in the future. The plain meaning of the words in the statute is that the jurisdiction of the Department extends to the floodplain on the basis of a 50-year flood frequency using the hypothesis of conditions as they exist at the time of the determination.

However, some courts have held that the failure to comply with statutory procedures could be justified in emergency circumstances. Ramsey v. Stevens, 283 N.W.2d 918 (Minn. 1979).

4. Adequacy of regulatory objectives--floodplain management regulations are valid only if they have a direct and substantial relation to the objectives of the police power; i.e., the preservation of the public health, safety, morals, and general welfare. 3 Rohan Zoning and Land Use Controls at

a) Limitation of land uses solely for the benefit of the general public—
courts have held that regulations which limit uses solely for the benefit
of the public are confiscatory and unconstitutional. City of Plainfield
v. Borough of Middlesex, 173 A.2d at 787 (1961):

Thus, plaintiffs are limited by the ordinance to using the property
for a school or for public parks and playgrounds. They are barred
from developing the land for residential or business purposes. It
naturally follows that plaintiffs' potential buyers are equally
limited as to use. Plaintiffs, under the ordinance, in order to
realize the economic value of the property, must therefore find some
purchaser who will either build a school or use the property for
public parks or playgrounds. While it is conceivable that they could
find a private school willing to build on the property, as a practical
matter the effect of the zoning ordinance is to limit the purchaser to
defendant borough or to the Board of Education of the Borough of
Middlesex. While the separate legal entities of the two are recog-
nized, nevertheless, together they represent in fact a single buyer,
that is, the people of the Borough of Middlesex. The net result of
the ordinance is to destroy for all practical purposes the full value
of plaintiffs' property and to leave plaintiffs at the mercy of
defendant as to the price that the latter may be willing to pay.
However desirable the property may be for defendant for parks and
playgrounds, defendant cannot use its power to zone as a method of
depreciating the value of the property for the purposes of purchase.

Also, see Dooley v. Town Plan and Zoning Commission of the Town of
Fairfield, 197 A.2d at 772, 773 (1964).

(1919).

c) Protection of fisheries—Zabel v. Tabb, 430 F.2d 199 (5th Cir. 1979).

d) Protection of wildlife habitats—Potomac Sand and Gravel v. Gov. of
Maryland, 293 A.2d 241 (1972).

e) Flood-related objectives:

i) Preserve and maintain the ground water table—Turnpike Realty Co. v.
Town of Dedham, 284 N.E.2d 891 (1972).

ii) Protection of public health and safety—Turnpike Realty Co. v. Town of
Dedham, 284 N.E.2d 891 (1972); Subaru of New England, Inc. v. Board of
Appeals of Canton, 395 N.E.2d 880 (1979); Moskow v. Commissioner of

iii) Safeguard property against the hazards of flood water inundation—
Turnpike Realty Co. v. Town of Dedham, 284 N.E.2d 891 (1972).
iv) To protect the community against the cost of flooding resulting from inappropriate land use—Turnpike Realty Co. v. Town of Dedham, 284 N.E.2d 891 (1972); Moskow v. Commissioner of Environmental Management, 437 N.E.2d 750 (1981).


vi) Protection of floodplain storage capacity—the Massachusetts Supreme Judicial Court upheld floodplain regulations where evidence was presented that a development would result in an increase in flood height of only 1/4 inch. Subaru of New England v. Board of Appeals, 395 N.E.2d at 883 (1979):

[3,4] Although the judge concluded that the proposed construction would only have a minimal effect on the water storage capacity of the flood plain district, we hold that it is "the board's evaluation of the seriousness of the problem, not the judge's, which is controlling." Copley v. Board of Appeals of Canton, 1 Mass. App. 821, 296 N.E.2d 716 (1973). The evidence, see n.3 supra, indicates that there was a basis for the board's concern as to lost storage capacity, and that reasonable persons could differ as to the severity of danger from flooding. In such circumstances the board's decision was not arbitrary and must prevail.

vii) Protection of landowners from victimization—regulations have been held to be invalid where subdivisions are approved without adequate consideration for resulting drainage problems. Hamilton v. Matazzaro, 293 A. 2d 450 (1972).

5. Reasonableness—the courts have considered the extent to which regulatory standards could reasonably accomplish regulatory goals:

a) Flood frequency—some cases have specifically upheld regulations which regulate areas flooded by storms of certain specified frequencies, i.e., 50 years or 100 years. A.H. Smith Sand and Gravel Co. v. Dept. of Water Resources, 313 A.2d 820 (Md. App. 1974); Maple Leaf Investors v. Department of Ecology, 565 P.2d. 1162 (1977). Other cases have sustained highly restrictive controls based on historic flood data although no frequency was assigned to the flooding. Kusler, J. "Flood Plain Regulations" in Floodplains and Wetlands: Legal Constraints and Options, January, 1981; Turner v. County Del Norte, 24 C.A.3d 311 (1972).

b) Reasonable economic use—the Massachusetts Supreme Court found that
agricultural and recreational uses alone are not "practical" uses to which the property in question could be put. MacGibbon v. Board of Appeals of Duxbury, 340 N.E.2d at 491 (1976):

We accept the judge's finding that the board's denial of the permit was not solely to preserve the area in its natural state, but we think his conclusion that there are practical uses to which the property can be put misconceives the applicable standard. The possible uses found, for agriculture and recreation, do not appear to be "practical" in the sense used in MacGibbon II. As one of the board's experts testified, "the uses to which the property may be put include--and some of these may sound facetious, but they're not--bird watching, hiking--these are actual uses that people have, do make of such properties, similar properties looking at the water,... just simple pride of ownership, just to say that they own a piece of the salt marsh, flying model airplanes or kites, growing marsh hay, which at one time was a very strong use of marsh, very prevalent use I should say, to protect the view, to provide a view.... Of course, one, obviously, is conservation...."

However, Turner v. County Del Norte, 24 C.A. 3d. 311 (1972) upholds the absolute prohibition of residential or commercial structures in a floodplain.

The courts have alternately supported the preference of single-family to the exclusion of multi-family development within a floodplain Kropf v. City of Sterling Heights, 215 NW2d 179 (1974) (favors single family); American National Bank and Trust Co. v. Village of Winfield, 274 NE2d 144 (1971) (favors multi-family, because "more economical" increases property values. 3 Rohan, Zoning and Land Use Controls at §18.01 [1]).

c) Mapping accuracy--the Courts have generally upheld floodplain regulations despite lack of data and vagueness as to the susceptibility of a property to flooding. Iowa Natural Resources Council v. Van Zee, 158 N.W.2d 111 (1968); Ravalese v. Town of East Hartford, 608 F.Supp. 575 (D.C. Conn. 1985).

The courts have also suggested that map inaccuracies could be remedied through a permit procedure. Just v. Marinette, 201 N.W. 2d 761 (1972); Turnpike Realty Co. v. Town of Dedham, 284 N.E.2d 891, 899 (1972).

Several cases have sustained suspensions of communities by the Federal Insurance Administration where the communities had argued that they should not be required to adopt regulations due to map inaccuracies. Kusler, Floodplain Regulations... at 11-20; Roberts v. Secretary of Department of Housing and Urban Development, 473 F.Supp 52 (1979).
d) Cumulative impacts--the courts have generally upheld the validity of considering the cumulative impacts in evaluating developments, or in establishing channel encroachment lines. Young Plumbing and Heating Company v. Iowa Natural Resources Council, 276 N.W.2d 377 (1979); Subaru of New England, Inc. v. Board of Appeals of Canton, 395 N.E.2d 880 (1979). However, in certain factual situations, the courts have found insufficient evidence of cumulative impacts. MacGibbon v. Board of Appeals of Duxbury, 340 N.E.2d 487 (1976).

e) Existing and Future Conditions--the courts have reacted somewhat inconsistently when considering whether floodplain mapping must be based on existing (pre-development) or future (post-development) flooding conditions. Both in A.H. Smith Sand and Gravel Co. v. Department of Water Resources, A.2d 820 (1974), and in Roberts v. Harris, 473 F.Supp. 52 (E.D. Miss. 1979), the courts have upheld the validity of flood maps based on existing conditions or historic data. However, in Young Plumbing and Heating Co. v. Iowa, 276 N.W.2d 377 (1979), the court endorsed efforts to project future flooding conditions.

f) Floodway prohibitions--the courts have become more understanding of the relative dangers of building within the floodplain, and have generally recognized the extreme dangers of building in a floodway. Vartelas v. Water Resources Commission, 153 A.2d 822 (1959); Young Plumbing and Heating Co. v. Iowa, 276 N.W.2d 377 (1979). However, in one case, the Supreme Court of Rhode Island was reluctant to prohibit building within an existing developed area, despite its presence within a "high flood danger" district. Annicelli v. Town of South Kingston, et al., 463 A.2d 133 (R.I. 1983).

g) Equal protection--although not commonly raised in floodplain cases, the courts have generally upheld the concept of equally protecting all landowners who are similarly prone to flood dangers. The Iowa Supreme Court upheld the concept of "equal degree of encroachment" in Young Plumbing and Heating Co. v. Iowa Natural Resources Council, 276 N.W.2d 377 (1979). An indirect application of the equal protection doctrine can be seen in Annicelli v. Town of South Kingston, 463 A.2d 133 (1983) which invalidated the town's effort to prohibit construction in an already developed coastal beach area.
h) Public trust doctrine:

This ancient doctrine, dating back to its Roman roots, declares that the sovereign holds title to, or has some special interest in, navigable waters and tidelands, for the benefit of the general public. The sovereignty is, so to speak, shared: The states determine whether tidal land below high water can be privately owned, but the federal servitude under the commerce clause of the U.S. Constitution, determines whether land ownership is public or private. Even in the few states which hold that the upland owner can own the land as far as low water, such land is still subject to certain public rights of navigation, commerce, and fishing. Thus, riparian owners may have special rights "as against individuals, or the unorganized public" which must yield to the rights of "the general public, as organized and represented by government." Rathkopf, Law of Zoning and Planning, at §7.07[2].

In Just v. Marinette, the Wisconsin Supreme Court applied this doctrine, declaring that "(a)n owner of land has no absolute and unlimited right to change the essential natural character of his land so as to use it for a purpose for which it was unsuited in its natural state and which injures the rights of others." Id. at 18, 201 N.W.2d at 768.

i) Preemption--it is inevitable that governmental regulation of floodplains will at times overlap. Where state and local regulations apply to the same floodplain, there is often the question of state preemption over local ordinances. In one case involving a challenge to a county's power to zone and regulate tidal waters, the court ruled that the state did not preempt local zoning, concluding that improvements, such as the building of a dock, constituted an extension of land, and could therefore be regulated by zoning. Harbor Island Marina, Inc. v. Board of County Commissioners of Calvert County, Maryland, 407 A.2d 738 (1979). The Connecticut court reached an entirely contradictory opinion in a parallel case. Town of Darien, et al. v. Frank E. Evans, et al., Court of Common Pleas, Fairfield County (Stamford) No. 1 96 63, June 27, 1978, 4 C.L.T. 38 at 16 (Sept. 18, 1978). In a situation concerning a challenge to local authority to regulate a riverine floodplain where the state maintains channel encroachment lines, the Connecticut Attorney General recently ruled that there was parallel jurisdiction (February 28, 1986).

j) The taking issue--in most floodplain cases, the claim of "taking" without just compensation is a key issue. In nearly all recent cases, the courts have found that there was no taking. In the few cases in which a finding of taking was made, it was due to inadequacies of the regulations, i.e.,
insufficient data to determine the flood-proneness of a property.

i) U.S. Supreme Court--the nation's highest court ruled on the taking issue in two non-floodplain cases which have application to all floodplain cases.

1) *Penn Central Trans. Comp. v. New York City*, 438 U.S.104 (1978). The court decided that Penn Central had a reasonable return of investment in light of the use and similar uses owned by Penn Central; it noted that a mitigation scheme to transfer development rights had value, and did mitigate the impact of the zoning bylaws.

2) *Agins v. City of Tiburon*, 598 P.2d 25 (1979): In this case the California court sustained "residential planned development and open space" zoning regulations, strongly endorsed the discouragement of premature conversion of open space, and held that the landowner had not shown that he was deprived of economic use of his land. Kusler, J. *Floodplain Regulations...* at 11-27, 28.

ii) Tests for determining a taking:

1) The taking issue is considered in combination with other legal issues:
   (a) Validity of objectives
   (b) Reasonableness
   (c) Due process
   (d) Equal protection

2) THE TEST: Do regulations deprive the land owner of all reasonable and economic use of his land?

3) Some selected tests and factors:
   (a) Did the landowner seek a permit?

The courts have found that in the case of a landowner who does not seek a permit to perform development activities, where a permit process exists, that there are no grounds for a finding of *per se* unconstitutionality, *State v. Johnson*, 265 A.2d 711 (Me. 1970) *Ravalese v. Town of East Hartford*, 608 F.Supp. 575 (D.C. Conn. 1985). In *Ravalese*, the court found that:

The thread running through these cases is that a taking occurs only when a landowner, though left with title, is deprived of all reasonable or practical use of his property.
Such is not the predicament of plaintiff herein. Under Article VI - Special District Zoning Regulations of the Town of East Hartford, although land use with a flood hazard zone is regulated, a landowner is not deprived of substantially all worthwhile benefit in or use of his property. A Development Permit for a flood hazard zone, Section 612.1, may be granted or denied by the Planning and Zoning Commission. Section 612.2. A variance from the ordinance can be requested of the Town's Zoning Board of Appeals, Section 612.4, subject to consideration of specified factors including any danger that materials from the proposed facility will be swept into others' lands; the importance of the proposed facility to the community; the compatibility of the proposed use with existing and anticipated development; and the effect on costs of governmental services during and after a flood. Section 612.4a. Also, flood hazard zone construction standards are set forth. Section 613. Clearly at least limited use of the land is thereby permitted.

Id. at 579, 580.

(b) Is there reasonable economic use of the property?
   In considering economic use, the entire property, including non-floodplain areas (uplands) must be considered. Spiegle v. Borough of Beach Haven, 281 A.2d 377 (N.J. App. 1971). Thus, the use of upland areas can be considered a reasonable economic use, even if floodplain development does not occur. The courts have considered that uses limited solely to parks, recreation, and agriculture, or the "minimal allowable use", to the exclusion of residential and commercial uses, are permissible. Turner v. County Del Norte, 24 C.A. 3d 311 (1972). Turner also held that proposed uses which would have increased flood heights or subject uses to severe flood damages were not reasonable.
   However, a number of cases have found that a taking occurs if the land cannot be used for any reasonable or practical purpose. Morris Country Land Improvement Company v. Township of Parsippany-Troy Hills, 193 A.2d 232 (1963); Dooley v. Town Plan and Zoning Commission of the Town of Fairfield, 197 A.2d 770 (1964); Annicelli v. Town of South Kingston, 463 A.2d 133 (R.I. 1983).

(c) Are the permitted uses essentially limited to public uses?
   On a similar note, a finding of taking has been made when ordinances have limited floodplain uses for essentially public

(d) What are the owner's investment-backed expectations?

Always an issue in taking claims is the amount of investment and the development expectations of the property owner. One court ruled that prior knowledge of statutory impediments would render any hardship to be self-imposed. Claridge v. New Hampshire Wetlands Board, 485 A.2d 287 (N.H. 1984) In Claridge, the court noted that:

(a) person who purchases land with notice of statutory impediments to the right to develop that land can justify few, if any, legitimate investment-backed expectations of development rights which rise to the level of constitutionally protected rights. Id. at 291.

However, in Sturdy Homes v. Town of Redford, 186 N.W.2d 43 (1971), the court dismissed the prior knowledge argument.

(e) What is the degree of hazard to the public?

The near absolute prohibition of development in floodways has been upheld (See Floodways this outline). The courts have also upheld the notion of considering the cumulative impact of filling in floodplains (see Cumulative Impact, this outline).

The question of degree of hazard is based on the notion that interests that are placed at risk are human health and safety, Law of Zoning and Planning at §7.07. The motive of keeping land in its natural state for fiscal or social reasons has not been well received in one New Jersey case. Morris County Land Improvement Company v. Township of Parsippany-Troy Hills, 193 A.2d 232 (1963).

(f) Do regulations prevent a nuisance?

The courts have consistently held that prevention of land use activities which constitute a nuisance is not a taking, because no landowner at common law has a right to make a nuisance of himself. Kusler, Floodplain Regulations, at 11-28; Turner v.
County Del Norte, 24 C.A.3d 311 (1972).

(g) Do the regulations balance interests?
The courts generally balance the need to society for regulations against impact of these regulations upon private landowners. Where societal need is great, the impact will be on individual property owners, without a finding of taking. Kusler, Floodplain Regulations at 11-29. Subaru of New England, Inc. v. Board of Appeals of Canton, 395 N.E.2d 880 (Mass. 1979).

(h) Were benefits and burdens distributed equitably?
The courts have held, in some cases, that government actions which unfairly burden a few for the good of the many may be held a taking. Kusler, at 11-29. If all property owners who are subject to the same level of flood risk are regulated in this same manner, then flood loss reduction benefits, as well as burdens, accrue to all. Under these circumstances there is no taking. The cumulative impact/equal encroachment provisions espoused in Subaru and Young represent approaches which have been found to be equitable.

(i) Is diminution of value permissible?
The courts have traditionally held that some degree of diminution of property value can result from the adoption or enforcement of a floodplain regulation, without a taking occurring. Due to the paucity of cases on this point it is difficult to determine at which point diminution will constitute a taking. E. Haven Econ. Dev. Comm'n v. Dept. of Environmental Protection, 409 A.2d 158 (1979). The courts have largely focused on the related question of the denial of reasonable use.

(j) Was the natural suitability of the land destroyed?
Several courts have ruled under the Public Trust Doctrine that landowners have no right to destroy the natural suitability or capability of the land when uses injure the public; thus, no right is taken. Just v. Marinette, 201 N.W.2d 761 (1972).

k) Governmental liability
   i) General discussion--erosion of immunity defense
   ii) Liability for flood damages (structural flood control measures)
iii) Liability for construction of storm drainage which results in flooding of property owners.

iv) Liability for adoption of regulations
   1) Turner v. County Del Norte, 24 C.A. 3d 311 (1972)

v) Liability for negligent mapping
   1) Johnson v. Chatham, 306 S.E.2d 310
   2) Zinn v. State, 334 N.W.2d 67 (1983)

III. FLOODPLAIN MANAGEMENT THROUGH LAND USE REGULATION TECHNIQUES AND OPTIONS

A. Conventional Floodplain Zoning
   1. Incorporation into zoning through enabling legislation
      a) Separate and identifiable land use category--floodplain zone
         i) Identification of permitted uses
         ii) Identification of zone boundaries on zoning map
      b) Overlay zone
         i) Overlay over existing land use zones or districts
         ii) Imposition of development standards, as well as prohibitions on underlying permitted land uses
         iii) Boundaries based on floodplain/hydrologic study (adoption of boundaries by reference, i.e., FEMA maps)
   2. FEMA standard model ordinance
   3. Floodplain zoning/regulation in non-FEMA floodplains
      a) Necessity for hydrologic studies (protection against negligent mapping)
      b) Necessity to meet legal tests

B. Channel Encroachment Lines/Setbacks
   1. Description of technique
   2. Need for hydrologic studies

C. Regulation Beyond Floodplain/Wetland Limits
   1. Storm water management--incorporation as regulation standards
      a) "Q" peak runoff policies
      b) Comprehensive drainage studies
   2. Erosion and sedimentation control measures
   3. Setbacks
      a) Adoption of development standards
   4. Environmental impact assessment
D. Alternative Land Use Techniques as Mitigation Measures
   1. Cluster development
      a) Detached "open space subdivision"
      b) Attached housing
   2. Density transfer
   3. Transfer of development rights (TDR)
   4. Environmental quality district (EQD)
   5. Performance zoning
   6. Special permit
E. Other Techniques Which Regulate Activities in Floodplains.
   1. Inland and tidal wetlands regulations
      a) Local and state regulation
      b) Federal regulation
         i) §404 of Clean Water Act
         ii) §10 of Rivers and Harbors Act
   2. Coastal management
      a) Coastal zones

IV. FACTORS TO CONSIDER IN DRAFTING A LEGALLY DEFENSIBLE FLOODPLAIN ORDINANCE
A. Be Aware of Limitations of Enabling Act.
   1. Ordinance must fall within the limits of authority conferred by enabling act.
B. The Ordinance Must Fit Into the Format and Organization of the Zoning Regulations.
   1. Conflicting sections of the regulations must be identified and mended.
   2. Other ordinances/codes should be amended to reconcile conflicting or more restrictive requirements.
C. If the Community Is Participating in the National Flood Insurance Program (NFIP), the Ordinance Must Contain at Least Minimum Requirements of the Program.
D. The Procedure for Adopting the Ordinance Must Conform to the Statutory Proceeding Required to Amend the Zoning Regulations.
E. In an NFIP Participating Community, Amendment of the Ordinance (Including Floodplain Boundaries) Must Receive Prior FEMA Approval.
F. When Adopting or Amending the Ordinance, Provide Hydrologic Studies as Technical Support for the Adoption/Amendment.
6. It is helpful to provide a Citizens'/Developers' Guide which explains the purposes of the ordinance, a discussion of floodplain dynamics, and the standards for floodplain development—the guide should contain illustrations to enhance understanding of the technical aspects of the ordinance.

H. Draft Your Floodplain Ordinance With These Common Elements:

1. Statement of statutory authority—cite the law which gives powers to the municipality to adopt the ordinance.

2. Findings of fact—cite the negative impacts of flooding on the community's human, physical (environmental), and economic resources. In drafting these findings, consider how the courts have justified the regulation of floodplains.

3. Statement of purpose and objectives—consult the purposes found defensible by the courts.

4. Map reference—the ordinance must be tied to a floodplain map and associated hydrologic study. Map references cited in the regulations must be amended at each time that the flood boundaries are modified.
   a) Interpretive narrative—the ordinance (or floodplain map) should contain a narrative describing how the map is to be interpreted.
   b) Warning/disclaimer of liability—the ordinance or map should contain qualifying language which sets forth the legal limits of the ordinance's purposes and objectives; a statement should be included so that the community or any employee thereof is not held liable for any flood damages resulting from enforcement of the ordinance.

5. Enumeration of permissible uses (if separate land use zoning district)—uses should be listed which the community feels are compatible, subject to the ordinance's use standards.

6. Definitions—clear definitions of all terminology unique to the floodplain ordinance.

7. Use regulations—delineation of standards for development in the floodplain. A hierarchy of standards can be presented which relate to the degree of flood hazard in various sections of the floodplain (i.e., floodway, flood fringe, etc.).
   a) Two district approach—two separate flood districts, based on degree of danger to life and property
   b) Combination flood district and overlay—flood district established over
floodway; overlay district superimposed over existing zoning categories along flood fringe

c) If NFIP participating community, use regulations must comply with NFIP minimum standards.

d) Consider using more stringent use standards as a safety factor:
   i) freeboard
   ii) fill restrictions
   iii) restricting of certain uses

e) Reference technical manuals, if necessary.

8) Administrative provisions
   a) Procedure for processing application
      i) Use of special permit/special exception; commission approval
      ii) As-of-right provision: building inspector approval
   b) Use of decisional criteria must comply with minimum NFIP standards.
   c) Listing of performance conditions/standards
   d) Variances--in NFIP participating communities, provide minimum decisional standards. In these circumstances, the discretion of the Z.B.A. is limited by these standards.
   e) Mapping disputes--outline the administrative procedures for resolving mapping disputes.

9. Non-conforming uses--outline treatments of existing non-conforming uses in the event of partial or total destruction by flooding.

10. Cross-reference to other ordinances to which the standards might apply.

I. Be Aware of Periodic FEMA Revisions, and Amend Your Ordinance Accordingly.
   1. Discussion of current NFIP revisions, proposed rule making.

J. Discussion of Sample/Model Ordinances

IV. CONCLUSION
OUTLINE FOR A COURSE ON SELECTION AND DEVELOPMENT
OF A LOCAL FLOOD WARNING AND RESPONSE SYSTEM
(LFWRS)

Curt Barrett
National Weather Service, Office of Hydrology

I. SELECTION OF A LFWRS
   A. Introduction/Course Objectives
   B. Relationship of a LFWRS to the Entire Flood Mitigation Effort
   C. Selection of a LFWRS

II. DEVELOPMENT AND IMPLEMENTATION OF A LFWRS
    A. Obtaining Funds and Government Support
    B. Steps in Setting Up a Manual LFWRS
       1. Data collection
       2. Data transmission
       3. Forecasts/procedures
       4. Informing local officials
    C. Steps in Setting Up an ALERT System
       1. Data collection
       2. Data transmission
       3. Forecast component
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PART SIX
THE FUTURE OF FLOODPLAIN MANAGEMENT
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IMPROVING THE PRODUCTIVITY OF FLOODPLAIN MANAGEMENT

Research Needs Identified
by the
Association of State Floodplain Managers

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Introduction

Progress in floodplain management, as in other endeavors in our society, requires constant attention to productivity. Productivity can be increased on the job by looking for new and better ways of undertaking the many tasks that make up the daily routine of the floodplain management professional. Often, however, achieving significant improvements in productivity requires solutions to problems that are so complex they demand more resources—time, money, and expertise—than individual professionals can bring to bear.

Floodplain management professionals must rely on organized research to solve the basic and practical problems that stand as barriers to improved performance. In this report, the Association of State Floodplain Managers identifies important research needed to improve the productivity of floodplain managers in state and local government. In addition, a number of suggestions for federal policies to increase floodplain management productivity are also offered.

Organized research involves four groups of people: researchers, administrators, budget makers, and users. A group of users, such as the Association of State Floodplain Managers, cannot assume that problems standing in the way of improved productivity will be addressed adequately unless it communicates its needs to each of the other three groups. Researchers look to users to help identify critical gaps in knowledge so that the information they produce is accepted and applied. Administrators who secure funds and allocate research resources look to users for advice when they formulate research programs and for support when they bring their programs to budget offices and legislative bodies. Budget makers want to know that funds appropriated for research serve the public interest by meeting real needs; they look to users to ratify proposed research agendas put forward by researchers and administrators.

This report is the first step in a two-step effort by the Association of State Floodplain Managers to improve the productivity of floodplain management by
advertising research to address user-defined problems. The second step is to communicate these needs effectively to researchers, administrators, and budget makers in Congress and state legislatures.

A New Way of Looking at Floodplain Management

The primary goal of floodplain management is to secure wise decisions about the use of flood hazard areas. Wise decisions do not necessarily require non-use of the floodplain, but they do require adjustments to building and other activities so that they reflect the risk of property damage, personal injury, and loss of life posed by flooding. Viewed in that way, improving the productivity of floodplain management can be looked at as a product development and marketing problem: how best to persuade various target groups (individuals, households, firms, and governments) to adopt one or more products (new ways of using or, when appropriate, not using flood hazard areas). The products floodplain managers develop and distribute include information about flood hazards; technologies related to flood warning, floodproofing, flood control, and land use; regulatory systems governing building and land use in flood hazard areas; flood insurance; and response, relief, and rehabilitation following flood disasters.

Floodplain management tasks are analogous in many ways to the "four P's" of marketing management taught in the nation's schools of business administration. They involve decisions related to 1) product development, 2) price, 3) place, and 4) promotion. Because floodplain management is a governmental activity, we can also think of a fifth "P" -- politics. The research needs discussed in this report are organized by those five floodplain management tasks, the common base of knowledge that underlies all five, and the planning and management methods needed to put them together into an integrated program.

Product development is self-explanatory. Tasks include designing floodplain management methods and techniques (information, flood warning, floodproofing, etc.) and testing them to see that they work effectively. Better products are easier to sell and are more likely to be adopted by target groups. However, improving productivity by designing better products requires resolution of a number of difficult problems identified in this report.

Price is often not considered in floodplain management, since, with the exception of flood insurance, many products are thought of as free. In fact, however, every floodplain management product has a price in terms of the time, effort, and
(often) funds that target groups must devote to (or give up for) its use. Products that are reasonably priced in terms of the value they deliver are easier to sell and are more likely to be adopted by target groups. Improving floodplain management productivity by manipulating product prices, however, requires better information than is available now about product performance and target group needs.

Place also is often not considered in floodplain management, since floodplain managers lack discretion about where programs originate. Yet place—whether products are delivered by federal, state, or local governments or by the private sector—obviously can affect whether target groups will adopt various floodplain management products. Land use regulations, for example, may be more acceptable if delivered by local governments than by the states or federal government. Place also may have another important effect on floodplain management productivity; the more places from which any given product is delivered, the more likely target groups are to use or abide by it. Land use regulations, for example, may be more likely to affect development decisions if complementary regulations are delivered by both state and local governments. Improving the productivity of floodplain management by maximizing the places delivering various products seems desirable, but not much is known about how target groups perceive the various sources of floodplain management products or how products originating with different agencies and levels of government can be integrated effectively.

Promotion is the set of activities involved in letting target groups know about the existence of floodplain management products, informing them about the benefits of those products, and persuading them to use the products. Promotional methods include publicity, advertising, and personal selling. Possibly because floodplain management is a governmental activity, promotion has received relatively little attention, even though a well-designed product, delivered at an attractive price, will not achieve program objectives if no one is persuaded that its use will be beneficial.

Politics is the set of activities required to enact floodplain management programs into law, secure funding for program implementation, and assure continued support over time. Even though every governmental activity is by its very nature political, floodplain management politics—how to operate effectively in political arenas—has received virtually no attention from either floodplain management professionals or researchers.

Undergirding the five P's is background information about the nature and causes of flooding and about target groups affected by flooding. That information is
necessary to design products that work—that reduce flood losses to persons and property—and that meet real needs of people and communities and thus will be adopted because they serve a useful purpose and are congruent with (or consciously attempt to change) target group attitudes and beliefs.

The final area of research needs considered here relates to the planning and management (including monitoring and evaluation) of floodplain programs. No matter how creatively floodplain managers devise measures with optimal product, price, place, and promotional characteristics—measures that are also politically sound and based on a thorough understanding of flood hazards and target group needs—individual products have to be put together to form floodplain management programs, product and program accomplishments have to be monitored, and adjustments have to be made in response to shortfalls in performance and other unforeseen difficulties. Floodplain managers can draw on the general planning and management literature for help in program planning, management, and evaluation, but some aspects of those tasks involve unique problems that can only be addressed adequately through research.

Research Needed to Improve Productivity

The list of 145 research needs that follows is based on information provided by floodplain managers in response to the following question: "What do you need to know to do a better job of floodplain management?" The 68 members and friends of the Association of State Floodplain Managers who responded represent floodplain management professionals working with five federal agencies and departments, 25 state and provincial governments, ten local governments, six consulting firms, and five universities and other nonprofit organizations.

A. BACKGROUND INFORMATION

1.0 Nature and Causes of Flooding

1.1 Identification of Flood Hazards

1.11 Develop hydrologic and hydraulic methods to provide more accurate delineation of flood hazards for:

1.111 Small watersheds,
1.112 Watersheds undergoing urban development,
1.113 Alluvial slopes and fans,
1.114 River reaches affected by tides,
1.115 Terminal lakes,
1.116 Snow-covered areas,
1.117 Mud flows and mud floods,
1.118 Areas subject to subsidence,
1.119 Long-term effects of sea level rise.

1.12 Evaluate which hydrologic-hydraulic methods (e.g., HEC-1, WSP-1, SWMM, TR-20, etc.) are most appropriate for use in flood insurance studies in different regions and types of flood hazard areas.

1.13 Establish ways of providing base flood elevations for unnumbered A zones on Flood Insurance Rate Maps for communities which do not have a Flood Insurance Study.

1.14 Develop simplified methods for identifying floodways prior to more detailed flood insurance studies.

1.15 Develop low-cost procedures for topographic mapping of flood hazard areas.

1.16 Develop low-cost procedures for updating flood hazard maps.

1.17 Develop reliable flood hazard delineation for individual properties, specified in terms of the risk of economic loss and loss of life, that takes into account the four principal flood hazard parameters (depth, velocity, duration, and sediment concentration); recognizes estimation uncertainty; and can be adjusted to take advantage of information on changes in tributary hydraulic conditions.

1.18 Determine when debris load should be added to "clean" flows.

1.19 Determine whether there are practical alternatives to the equal conveyance reduction floodway models that would be more appropriate in low relief coastal floodplains.

1.20 Identify types of land use that are compatible with floodplain management objectives.

1.21 Identify activities that can occur within floodways without obstructing flood flows and that do not require engineering analysis before they are built.

1.2 Flood Impacts

1.31 Develop a low-cost system for collecting and disseminating data on flood events that provides information on:

1.311 Flood depth, velocity, duration, and associated sedimentation;
1.312 Flood losses, including losses to:
    1.3121 Structures located outside of the 100-year floodplain.
    1.3122 Structures repeatedly damaged.
    1.3123 Structures damaged due to storm water drainage problems.
1.32 Identify the distribution of national flood losses in V, A, B, and C zones by region.

1.33 Develop depth-damage data that are construction type and material specific.

2.0 Target Groups Affected by Flooding

2.1 Target Group Characteristics

2.11 Prepare software necessary to gather machine-readable census data for flood hazard areas.

2.12 Identify types of land uses that are functionally dependent on location on or near flood hazard areas.

2.13 Inventory public facilities located in flood hazard areas.

2.2 Target Group Knowledge, Beliefs and Attitudes

2.21 Measure public perceptions of flood risk, reaction, response, and recovery (including economic, political, psychological, and social dimensions).

2.22 Measure the stability over time of individuals' attitudes toward flood hazards and identify factors that account for changes in attitudes.

2.23 Determine the proportion of floodplain property owners/occupants who are aware of the National Flood Insurance Program.

2.24 Identify priority technical assistance needs of local floodplain managers.

2.25 Identify additional information about the NFIP, if any, needed by local officials to adequately administer a sound floodplain management program.

2.26 Determine the level of accuracy of flood hazard data that is desired by communities.

2.3 Target Group Decisions and Behavior

2.31 Determine whether individuals or households/families are most likely to make decisions about flood hazard adjustments, including the purchase of insurance.

2.32 Ascertain what factors (including extent of marketing, marketing techniques such as "Write Your Own," and insurance premium rates) influence consumer decisions to purchase and renew flood insurance.
2.33 Examine locational decisions to determine the extent to which loca­
tional choices are affected by the flood hazard, various flood hazard
adjustments, including the availability of flood insurance, and state
and local floodplain management programs.

2.34 Determine at what depth of flooding property owners begin to think
seriously about floodproofing and other measures to reduce future
flood damages.

2.35 Determine the extent to which real estate agents and lenders inform
their clients of flood hazards.

B. THE FIVE P's OF FLOODPLAIN MANAGEMENT:
PRODUCT, PRICE, PLACE, PROMOTION, AND POLITICS

3.0 Product Development

3.1 Flood Warning

3.11 Compare components, hardware and software of currently available flood
warning systems to determine their relative strengths and weaknesses.

3.12 Develop a computerized flood warning system which is able to collect
and assess real time hydrologic data, process the information in
programs that assess specific properties and can be accessed by
personal computers, and provide the information to graphics terminals
that can simulate flood effects on those properties.

3.2 Floodproofing

3.21 Inventory and describe (including costs) floodproofing and other
techniques communities and individuals have used to protect existing
development from flooding.

3.22 Develop and evaluate nonstructural options for dealing effectively
with the flooding problems of older, fully developed areas.

3.23 Develop floodproofing techniques for recreational facilities, such as
trails, boardwalks, decks, and underpasses.

3.24 Identify and evaluate financial and other incentives to encourage
property owners (particularly low- and moderate-income households) to
adopt floodproofing measures.

3.3 Relocation

3.31 Develop guidelines for evaluating when structures should be relocated
out of flood hazard areas and estimate national economic development
benefits of floodplain evacuation/relocation.
3.32 Identify sources of federal assistance for relocating structures from flood hazard areas.

3.4 Regulations

3.41 Building Regulations

3.411 Determine under what conditions and over what span of time the practice of declaring a "constructive total loss" would be a cost-effective method of reducing flood damage insurance claims and mitigating flood hazards.

3.412 Develop standards for safe construction practices in floodplains located in seismic hazard areas.

3.413 Develop standards for safe construction practices on alluvial slopes.

3.414 Develop guidelines for local regulation of basement construction in flood hazard areas.

3.42 Land Use Regulations

3.421 Identify communities that have prohibited floodplain development and indicate in which circumstances that is a reasonable course of action.

3.422 Develop access standards for floodplain development.

3.423 Develop methods of regulating land development around lakes with fluctuating shorelines.

3.424 Conduct legal analyses to determine the extent to which the use of property can be restricted before the courts determine that a taking has occurred.

3.425 Conduct legal analyses to identify public responsibilities and local officials' legal liability resulting from private sector decisions to locate in flood hazard areas.

3.426 Identify and evaluate the use of financial incentives and penalties to secure appropriate land uses in flood hazard areas.

3.427 Assess the advantages and disadvantages of performance versus prescriptive standards in floodplain regulation and management.

3.43 Grading/Filling Regulations

3.431 Develop model ordinances and other procedures for more effectively controlling filling, grading and other nonstructural activities occurring in floodplains.

3.44 Storm Water Management Regulations

3.441 Identify and assess standards communities have used in regulating urban storm water management practices.

3.442 Assess whether and under what circumstances storm water management and other development regulations should require developers to pay for the off-site costs of storm drainage improvements necessitated by watershed development.
3.45 State Regulations

3.451 Inventory state floodplain management regulations and procedures states are using to enforce those regulations.
3.452 Inventory and evaluate state laws governing storm water management.

3.5 Greenways and Other Open Space Programs

3.51 Inventory and describe community floodplain greenway and other open space programs (funding, use of mandatory dedication requirements in development codes, integration with floodplain management).
3.52 Identify techniques communities have developed for patrolling and maintaining greenways and other floodplain open space and recreational areas.

3.6 Information and Technical Assistance

3.61 Public Information

3.611 Formulate methods for improving public awareness of flood hazard areas and public appreciation of the need for floodplain management.
3.612 Identify what communities have done to enhance the basic flood hazard maps provided by the Federal Emergency Management Agency, including community-originated flood hazard mapping.
3.613 Identify ways to improve the quality of floodplain maps (see also section 1.1 above for research needs related to flood hazard delineation).
3.614 Formulate methods communities can use to increase the attention given to flood hazards in the decisions of landowners, investors, speculators, and others who trade in land with potential for urban development.

3.62 Technical Assistance

3.621 Identify the best methods of informing and training local officials in the goals, art, and science of floodplain management.
3.622 Identify techniques for increasing the depth of knowledge of floodplain management among local government personnel so constant training as personnel turn over is not needed.
3.623 Identify the best methods of helping local officials comply with requirements of the National Flood Insurance Program.
3.6231 Identify methods of informing local floodplain managers about the types of information needed to support requests for revisions in flood insurance maps.
3.6232 Identify the most effective tools for helping communities in the emergency phase of the NFIP convert to the regular phase.
3.624 Determine the optimal frequency with which state and federal officials should visit local communities to provide technical assistance.

3.7 Flood Insurance

3.71 Assess the feasibility of subsidizing flood insurance for low-income households in order to increase market penetration.

3.72 Assess the feasibility of returning 20 to 30% of the premiums generated within a state to state and local governments for use in floodplain management programs.

3.73 Explore the application of insurance principles to deal with losses to public infrastructure located in flood hazard areas.

3.8 Flood Control

3.81 Levees

3.811 Determine how deep levee linings should extend below the design flow line.

3.82 Channel Improvement and Maintenance

3.821 Determine how deep a stream bed stabilizer should be in a sandy desert wash.

3.822 Formulate flood control facility design standards that take into account overflow paths and obstructions of channels.

3.83 Storm Water Management

3.831 Inventory storm water management practices and assess the state of the art in terms of effectiveness, costs and benefits of different measures, and public acceptance.

3.832 Assess the advantages and disadvantages of dispersed detention versus regional detention.

3.833 Identify improvements to storm sewer inlets to increase their capacity.

3.84 General

3.841 Identify large-scale flood control measures that can be undertaken with a minimum of environmental damage.

3.842 Identify financial incentives, other than federal grants, to encourage community adoption of hazard mitigation measures.

3.9 Disaster Response, Relief, and Recovery

3.91 Assess the costs and benefits of tying public facility reconstruction assistance to requirements to upgrade damaged facilities to 100-year or similar flood damage standards.
4.0 Price of Floodplain Management

4.1 Flood Hazard Delineation and Mapping

4.11 Develop simplified, low-cost methods for flood hazard delineation and mapping, including:

4.111 Identification of floodways prior to more detailed flood insurance studies.
4.112 Topographic mapping of flood hazard areas.
4.113 Updating floodplain maps.

4.2 Floodproofing

4.21 Develop effective floodproofing techniques, such as waterproof coatings, that require a minimum of human intervention to be effective.

4.3 Building and Land Use Regulations

4.31 Devise floodplain regulations, including enforcement mechanisms, that are effective in small towns, rural areas, and other jurisdictions that lack financial resources and highly trained technical personnel and often do not have a high enough volume of floodplain development to make such training or elaborate floodplain regulatory schemes cost-effective.

4.32 Develop methods to streamline floodplain permit application review.

4.33 Develop simplified procedures for identifying "substantial improvements" for regulatory purposes.

4.4 Flood Insurance

4.41 Find ways of reducing/stabilizing flood insurance premiums required to support the NFIP so that costs to consumers are reduced.

4.42 Determine whether rates charged for flood insurance outside of designated flood hazard areas (A zones) adequately reflect the probability of experiencing flood losses.

5.0 Places Delivering Floodplain Management Programs

5.1 Number of Places Participating in Floodplain Management

5.11 Identify ways of increasing the number of communities with well-designed floodplain management programs (as opposed to communities engaged in a collection of floodplain management activities mandated by federal and state legislation).
5.12 Identify ways of increasing the number of states with well-designed floodplain management programs (as opposed to states engaged in a collection of floodplain management activities mandated by federal legislation).

5.2 Coordination Among and Within Places Participating in Floodplain Management

5.21 Review existing federal, state, and local laws and regulations to identify conflicts which may limit the effectiveness of floodplain management.

5.22 Identify measures, actions, and assistance needed to establish state floodplain management roles that are complementary to federal and local programs and that lead to coordinated action toward common goals.

5.23 Determine whether standards embodied in federal and state floodplain management legislation and agency rules are consistent; where inconsistencies are found, suggest which standards are most appropriate.

5.24 Identify ways of better coordinating state floodplain management with complementary state programs, such as wetlands protection and dam safety, and with federal programs that affect those concerns.

5.25 Identify obstacles to and methods of better achieving coordination within the Federal Emergency Management Agency with respect to local floodplain management responsibilities, flood insurance coverage and rating, and damage to public property from disasters.

5.26 Evaluate the advantages and disadvantages of federal, state, or local assumption of responsibility for urban storm water management.

5.27 Develop ways of integrating floodplain management principles into other community programs.

5.3 Selection of the Most Appropriate Places for Delivering Floodplain Management Programs

5.31 Determine the relative benefits of federal financial support of local versus state versus federal floodplain management programs.

6.0 Promotion of Floodplain Management

6.1 Determine the most effective sources for communicating messages about floodplain management products, including both public and private sources and spokespersons.

6.2 Determine the most effective message strategies for raising target groups' awareness of flooding, arousing interest in floodplain management products, communicating product benefits, and persuading target groups to use those products.
6.3 Determine the most effective channels of communication, including consideration of the relative advantages and disadvantages of personal (face-to-face and telephone) and impersonal (media advertising, direct mail) tactics.

7.0 Floodplain Management Politics

7.1 Identify state legislation needed to promote effective local management of floodplains.

7.2 Identify techniques for persuading state legislatures to pass effective state floodplain regulations and other floodplain management measures.

7.3 Identify ways of persuading local governments to enact effective floodplain management programs.

C. PROGRAM PLANNING, MANAGEMENT, AND EVALUATION

8.0 Program Planning and Management

8.1 Develop methods for comparing alternative mixes of structural and non-structural flood hazard mitigation measures that might be applied within a single river basin or watershed.

8.2 Develop methods for estimating the intangible benefits of flood hazard reduction measures.

8.3 Develop procedures for integrating environmental and economic values in floodplain planning and management.

8.4 Local Floodplain Management Regulations

8.41 Determine which administrative arrangements at the local level are most effective in furthering the proper administration of floodplain management regulations.

8.5 Storm Water Management Planning

8.51 Identify methods of integrating water quality and flood control objectives of urban storm water management.

8.52 Identify staffing requirements for statewide storm water management enforcement programs.

8.6 Flood Forecasting/Warning System Planning

8.61 Formulate methods for designing and estimating the costs and benefits of flood warning systems.

8.7 Floodplain Management Personnel
8.71 Investigate the advantages and disadvantages of state certification or licensing of floodplain managers.

8.8 Floodplain Management Information Systems

8.81 Develop computer-based systems for managing flood hazard data.

8.811 Determine who should be responsible for managing and maintaining a centralized file (regional, state, or federal agencies).
8.812 Develop simplified methods for use of the system.
8.813 Evaluate whether database management software should be developed for distribution to local governments.

8.82 Assess the desirability and feasibility of computerizing data on property owner compliance/noncompliance with floodplain regulations.

8.83 Identify potential users of computer-based floodplain management information systems who should be given access to data (e.g., state, central office FEMA, regional office FEMA, local governments, regional agencies).

9.0 Product and Program Evaluation

9.1 Floodproofing Measures

9.11 Calculate flood damages averted through elevating and floodproofing structures.

9.2 Building and Land Use Regulations

9.21 Inventory and identify (by type) development allowed in flood hazard areas since passage of the National Flood Insurance Program.

9.22 Evaluate the effectiveness of local programs in achieving long-term flood damage reduction goals.

9.221 Evaluate the distribution of costs and benefits of local floodplain management programs to determine whether (or the extent to which) floodplain property owners experience financial gains or losses.
9.222 Evaluate whether communities are applying appropriate land use regulations to areas protected by levees, given the potential for levees to fail.
9.223 Evaluate the performance of specific flood-loss reduction tools and standards based on post-flood damage and other assessments.
9.224 Assess the accuracy of floodplain maps used in local regulatory programs.
9.2241 Assess the accuracy of unnumbered A zone designations.

9.23 Evaluate the effectiveness of state flood hazard management/regulatory programs (in comparison with local regulation and NFIP requirements).
9.24 Estimate how much money has been saved (damages reduced, taxes needed for relief payments saved, etc.) through flood losses averted by the National Flood Insurance Program.

9.241 Evaluate the effectiveness of the "substantial improvement" rule in NFIP regulations and, if found ineffective, propose improvements.

9.242 Evaluate the effectiveness of FEMA's creation of "Probationary Status" in correcting poor floodplain management practices and administration.

9.243 Evaluate the effectiveness (including enforceability) of current NFIP rules which allow breakaway walls in coastal areas and suggest changes in those regulations, if needed, to promote sound flood hazard management in coastal areas.

9.3 Disaster Response, Relief and Recovery

9.31 Assess current postdisaster relief and recovery policies in terms of both short- and long-term costs and benefits.

9.32 Assess the effects of increased federal cost-sharing requirements on the fiscal status of disaster-stricken local governments.

9.33 Assess the extent to which federal and state officials are complying with the 1980 OMB directive to coordinate postdisaster activities in order to ensure that federal funds are not spent unwisely to rebuild flood-damaged structures and that the desired result has, in fact, occurred.

9.4 Executive Order 11988

9.41 Evaluate the effectiveness of Executive Order 11988 in terms of agency compliance, flood damages averted, preservation of environmental values, and disbursement of funds.

9.5 Structural Measures

9.51 Measure the effects of jetties, seawalls, and groins on coastal erosion rates.

9.6 Determine the extent to which effectiveness evaluations are used to improve agency methods and procedures.

Changes in Federal Policy Needed to Improve Floodplain Management Productivity

In addition to identifying the subjects for research listed above, the federal, state, and local floodplain management professionals participating in this project identified several changes in policies of the Federal Emergency Management Agency that they thought would lead to immediate improvements in productivity. Those changes are outlined briefly in this section under four headings: floodplain maps,
required local land use and building regulations, flood insurance, and technical assistance.

A. Floodplain Maps

1.0 Improve maps so that they are more useful in floodplain management.

1.1 Provide more benchmark elevation reference marks on Flood Insurance Rate Maps.

1.2 Combine floodway and flood insurance rate maps rather than provide communities with two maps.

1.3 Include erosion in mapping coastal flood hazards.

1.4 Consider sea level rise in mapping coastal flood hazards.

1.5 Drop numbered A zones if they will not be explained in FEMA regulations.

1.6 Reduce the number of A zones.

2.0 Accelerate mapping of newly developing areas on the fringes of built-up areas.

3.0 Standardize hydrologic-hydraulic methods used in flood insurance studies in particular regions.

4.0 Contract with local rather than out-of-state firms to conduct flood insurance studies.

5.0 Establish clear policy regarding updating maps.

B. Land Use and Building Regulation

6.0 Demonstrate a stronger long-term commitment to floodplain management.

7.0 Investigate the feasibility of cost-sharing with local communities for flood insurance studies with an expanded scope of work that includes the development of alternative solutions to flooding problems identified by the study.

8.0 Provide more incentives for effective community floodplain management.

8.1 Establish a grant-in-aid program to support community floodplain management.

8.2 Return 20 to 30% of the flood insurance premiums generated within a state to state and local governments for use in floodplain management programs.

9.0 Increase efforts to monitor and enforce compliance with floodplain management requirements of the NFIP.
10.0 Provide better guidelines for relocation of structures from flood hazard areas.

11.0 Delegate authority to establish standards to regional offices or state governments so that standards reflect differences in flood hazards among different regions.

12.0 Allow small towns more than six months to adopt floodplain management ordinances required for participation in the NFIP.

C. Flood Insurance

13.0 Market flood insurance more aggressively.

14.0 Adjust insurance rates to reflect more accurately the probability of experiencing flood losses, particularly in coastal areas (V zones).

15.0 Subsidize insurance for lower income households.

16.0 Provide assistance to low-income households for floodproofing.

D. Technical Assistance

17.0 Support state community assistance programs.

17.1 Let states know what types of federal assistance they can expect in the future.

17.2 Devote more resources to support state-level community assistance programs.

18.0 Communicate more clearly in correspondence with communities.

19.0 Develop a manual that includes all FEMA policies, procedures, rules, and regulations regarding floodplain management.

20.0 Provide more specific guidance regarding allowable uses in floodways in FEMA manuals and other technical assistance documents.

21.0 Provide state and community floodplain managers with a list of how many insurance policies are in force and the value of coverage for specific communities.

22.0 Develop a list of state floodplain management personnel and their expertise and provide the list to communities as a resource for floodplain management.

Concluding Note

Tremendous strides have been made in floodplain management over the past two decades. The preceding lists of research and policy needs suggest, however, that much can be done to further enhance the performance of floodplain managers and
floodplain management programs. The research needs identified in this report are an important step in improving productivity, but this is only the first step.

If floodplain managers' research needs are to be met, they must be communicated effectively to three groups: researchers, administrators, and budget makers. To do that, the Association of State Floodplain Managers must take three additional steps. First, members of each of those groups should be identified. Second, the research needs enumerated in this report should be organized and presented so that members of each group can easily comprehend them and appreciate their importance. Third, the association should establish written and personal contact with members of each group in order to persuade them to address the association's research needs. This report concludes with some initial ideas for undertaking those three steps.

Researchers can be informed of the association's research needs in two ways. First, the association can reproduce the present report and distribute it by making copies available to interested persons at meetings attended by natural hazards researchers, such as the annual summer workshop in Boulder; also, a mailing list of persons active in natural hazards research can be compiled and copies can be mailed to them directly. Second, an article summarizing the association's research needs can be prepared and published in one of the professional journals serving natural hazards researchers.

Administrators in two types of agencies are appropriate recipients of information about the association's research needs. The first type consists of research agencies, such as the National Science Foundation, U.S. Geological Survey, Department of Commerce Sea Grant College Program, and the various state water resources research centers and institutes. The second type comprises various mission agencies, such as the Federal Emergency Management Agency and U.S. Army Corps of Engineers, which have substantial budgets for policy development and research. The association's list of research needs should be packaged in an attractive way and then delivered personally to key administrators in each research and mission agency. Follow-up support from floodplain managers within the agencies' various constituency groups should then be arranged so that administrators have a clear picture of the widespread interest that exists in seeing that these research needs are addressed.

Finally, contacts should be established with the Congressional committees that oversee each research and mission agency's budget. The association's interest in seeing that its research needs are addressed should be made clear, both by the association's chair and executive director in budget hearings, and by individual
association members living in the various budget committee representatives' districts and senators' states. It would be appropriate to point out the clear connection between improved productivity of floodplain management and reduced federal expenditures for disaster relief and rehabilitation. In addition, the association should ask for greater parity in federal disaster-related research expenditures, which now are heavily skewed toward research on earthquake hazards. A comparison of earthquake and flood losses and associated federal disaster relief expenditures over the past decade will clearly show that flood hazards should be given more attention in our national research agenda.
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LOOKING FORWARD

William G. Fry
Dewberry and Davis

In order to start "looking forward" to the future of floodplain management, we have to make a very quick analysis and some obvious observations about where we stand today. I am pleased to have been a consultant to the National Flood Insurance Program for over 12 years, and some of the things I am going to say are clearly personal observations; but, they are things I think we ought to discuss, even if some bias appears.

Nationally and politically, flood hazard mitigation and floodplain management are a reality. Politicians and community leaders know it, believe in it by and large, and accept it; and the federal government has several bureaucracies in place--FEMA, Corps of Engineers, the SCS--to support floodplain management and similar efforts.

Many, if not most, states are represented within the Association of State Floodplain Managers--in itself a significant fact. However, there are several--perhaps many--states that still give only lip service to our objectives or to the quid pro quo of the Flood Insurance Program.

On the local level, most communities that need flood insurance have it. Perhaps half of them are believers and push hard for the program; the other half fight it, do as little as possible, and simply try to reap the benefits of the program.

Private developers perform only the minimum required flood protection work, and one cannot ask or expect them to do more. In a presentation to the ASFPM conference, a private developer talked about reading the regulations of a community five times. I guarantee he does not read them so he can improve upon them when he goes into that community. He reads them so that he knows the minimum work required.

With regard to the Flood Insurance Program, the study effort is now practically over; there is no money left. The Flood Insurance Program is spending, I would guess, about 75% of its technical resources on revisions--revisions which, in large part, are undertaken to help people defeat the intent of the Flood Insurance Program and floodplain management.

Floodplain mapping technology is at a standstill (and to that I say, "Thank God"). The ability to identify, model, and map floodplains is more than sufficient to meet current needs and goals; we do not need any innovative changes. In the future, perhaps, some minor technological improvements might save some money, but breakthroughs permitting big changes are unlikely.
The preceding is the good news. However, "where we are today" and "where we will be tomorrow," without change, is a whole different story. I would like to offer seven observations about where we stand today and how things actually are:

1) There is the potential for a significant void in floodplain management leadership on both the local and federal level. The federal bureaucracies will not continue to be leaders as they have for the last ten years. The Federal Emergency Management Agency and the Corps of Engineers both stated at the ASFPM conference that their organizations were going through significant changes—changes which seem to indicate a withdrawal from leadership roles.

2) The Flood Insurance Program may have reached its economic and study goals, but it is a long way from being a sound floodplain management program in every community. This contradiction may become apparent in a very catastrophic way sometime soon.

3) The Flood Insurance Program cannot monitor or enforce floodplain management in 17,000 communities. A major shift, placing the technical and program responsibilities on the communities, must be made. In addition, there must be a strong program of substantial loss recovery through subrogation in order for the program to exist in the future.

4) Flood Insurance Program regulations must be changed to stop the revisions process, which allows floodplain changes which are intuitively harmful in the long run. At a minimum, the sanctity of floodways must be established. Once they have been identified, they must become inviolate to assure future flood hazard mitigation.

5) Economics still rule. Economic incentives need to be developed for the Flood Insurance Program and other efforts such as individual floodproofing, community actions, etc.

6) Joint ventures with other programs (wetlands, dam safety) should be considered, but floodplain management must not be compromised. We should recognize our common goals, but not subordinate our program.

7) Floodplain management and flood hazard mitigation have achieved recognition and respect, but, like all other painful accomplishments, progress made up to today could very easily be lost among new problems tomorrow. We may have just fought the first round, and the rest of the fight is yet to come.

Where does this leave us? And, who is "us"? "Us" are those who believe in floodplain management and, most importantly, the people who are members of and represented by the Association of State Floodplain Managers.
The current state of things that I have outlined above leaves the Association of State Floodplain Managers as the single most important entity in floodplain management for the near future. The association can no longer be just an advocate, it must be the leader. The organization has reached maturity and should now accept the corresponding responsibilities and obligations.

Thus, to ensure its future, the Association of State Floodplain Managers should:
1) Establish itself as a power and political force in the United States;
2) Become larger--it must have a broader base of membership;
3) Develop political action committees, local and national;
4) Become associated with known forces of reason--Common Cause and other known advocacy groups;
5) Develop a lobby on state and local levels;
6) Not accept the Flood Insurance Program as it is today, but review the whole process and impact of the program and see that it meets the needs of the future;
7) Support the movement toward reliance on states and local governments for floodplain management--as we have heard, the feds are on the way out.

It has been stated at the ASFPM conference that the Association of State Floodplain Managers has a new freedom, but to reach our goals and to be a viable organization ten years from now, this freedom has to be considered as much a burden as a blessing.
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I would like to look at the future and see what is in store for individual floodplain managers. To do this, I will review recent trends in flooding, floodplain development, and floodplain management. Building on these trends, I will also make some predictions about floodplain management programs and what can be expected of us as professionals.

Trends in Flooding

Flood damages are getting worse. We have constricted our rivers with levees, bridges, and sedimentation. We have increased watershed runoff by increasing farm drainage and urban development. For example, in 1973 one Arizona river's 100-year flood was estimated at 30,000 cfs. Today's estimate is 90,000 cfs. In short, there is more water coming down our streams and less room to carry it.

Floods seem to be less predictable. After a period of about 80 years of relative quiet, four federally-declared disasters have occurred on the Illinois River in the last six years. A study by the Illinois State Water Survey indicates that a wet cycle may be starting after a relative dry spell of 60 to 80 years. This means that our gauge records used for flood predictions may be no good.

We are faced with "new" types of flood hazards--at least they are new in that we have yet to develop responses for them. These include rising lakes, alluvial fan flooding, moving river beds, mud flows, and the scariest one of all, world sea level rise. It seems that once we think we have a handle on one problem, we discover another.

Trends in Floodplain Development

There are three national development patterns that are encouraging unwise floodplain development. The first is the move out of the big cities. Older cities that have been protected from flooding are losing their population to unprotected areas. In 1950, a major levee system protected 82,000 residents of East St. Louis from Mississippi River floods. Now there are only 55,000 East St. Louis residents protected by this government investment.

In addition, I have found that long time urban residents do not "read" the ground when they move to the country. They have trouble understanding that Mother Nature, not humankind, controls their environment. Too late, they realize the
results of filling in that open ditch so their yard will look prettier.

The second trend is the migration to the South and the West. While these regions have coastal shorelines and mountain valleys that are very attractive, those same regions are also subject to some of the country's most dangerous flooding.

Third, rural areas are being developed as people escape city living or acquire second homes. People are settling in areas that have the worst floodplain regulations in the country. In rural counties, small or part-time staffs cover large territories with minimal flood data. They also receive minimal support from the electorate and politicians whose philosophies oppose most types of regulation.

Even if every community were effectively regulated according to the National Flood Insurance Program standards, there would still be increased flood damages. There are several reasons for this. Current NFIP mapping techniques do not delineate all the hazard accurately, especially in arid regions. Buildings built to NFIP standards will be damaged by greater than 100-year floods. Flooding is occurring in areas that have not been mapped, such as rural areas and areas where there is less than one square mile of drainage.

A final problem concerning floodplain development is that existing flood-prone buildings are not going to disappear. Except in high-damage areas, such as coasts and mountain valleys, the substantial improvement regulations do not work. Partially damaged buildings are being repaired and rebuilt, and current acquisition programs are so grossly underfunded that they cannot do much to solve the problem.

Trends in Floodplain Management Programs

There will be fewer structural projects in the future. Levees, reservoirs, and channel modifications are getting more expensive, and there is less federal money available for such work. As General Hatch has said, we have undertaken all the "good" projects. The remaining unprotected neighborhoods are settled less densely so bigger projects are needed to protect the same number of citizens and dwellings. Benefit-cost ratios are coming closer and closer to 1:1. Most of the remaining flood problem areas are not going to receive structural protection because the necessary structures will not be cost-effective.

As a corollary to this trend, there will be more nonstructural projects in the future. Federal, state, and local agencies have done a lot of research into nonstructural measures. Many communities have experimented with them, and the techniques are becoming more widely accepted. With structural projects no longer
feasible, flood control agencies are becoming more willing to implement nonstructural programs, such as acquisition, floodproofing, warning systems, open space preservation, and development regulation.

As the theme of the 1986 ASFPM conference demonstrates, floodplain management projects, especially nonstructural ones, are becoming more dependent on local governments. Because there is less money to "bribe" local officials, those officials have become more aware of their options. In addition, there is an increasing desire to run programs at the local level, because there they can happen quicker and are not subject to numerous state or federal procedures and requirements.

More and more, floodplain management programs are going to be cooperative efforts. Cost sharing, watershed planning, and river basin commissions are examples of intergovernmental cooperation. There will also be more cooperation between communities and developers as the private sector donates flood easements or funds for storm water detention. Neighborhood groups and individuals are also becoming more willing to cooperate with community cleanup programs or to monitor floodplain development.

Cooperative efforts have the advantages of being cheaper for individual participants and more effective when dealing with large areas. However, both nonstructural projects and cooperative efforts are more difficult to plan and implement than structural projects or programs initiated by one entity. Floodplain management is getting more complicated, and planning and coordinating are becoming more important aspects of the job.

I predict that the importance of and controversy over development regulations will decrease. For one thing, there is a general attitude around the country that prevention is better than the cure. Witness health maintenance organizations, the wearing of seat belts, and neighborhood crime prevention programs. Additionally, even though we have a way to go, we are making some progress with state and local floodplain regulators. They are becoming more knowledgeable, more active, and more aggressive.

This year we celebrated the fiftieth anniversary of the Flood Control Act and the twenty-fifth anniversary of the Corps' Floodplain Management Services Program. We have another birthday to consider: 1986 marks the year that the first baby-boomers become 40 years old. Baby-boomers are no longer kids or entry-level employees. They now hold decision-making positions.

There are some characteristics of baby-boomers that I think we ought to recog-
nize. They do not like authority and they do not like bureaucracy. They are willing to challenge their superiors if they disagree with them. They are mobile and they are not married to their employer for life. They are well educated. Because there are more women in the traditionally male field of engineering, the members of that profession are now more socially conscious and concerned about people.

Future Floodplain Management Programs

Let me take all of these trends and put them together to make four predictions about future programs.

First, people will become more important. Structural projects do not directly affect people's lives. A floodplain resident may live blocks from a levee or miles from a flood control reservoir. For many people, a structural project is built by someone else to make a periodic problem go away.

On the other hand, nonstructural projects affect people directly. Purchasing, moving, or elevating a home has a major impact on the residents. Nonstructural projects are highly dependent upon popular support; regulations are dependent upon the cooperation of the builder; floodproofing requires the cooperation of the owner; warning systems depend upon the cooperation of the listener. If none of these people are willing to participate, there will be no flood protection.

Second, future programs will have more participation by local officials and property owners. There is a greater need for communities and property owners to share in project costs. By their very nature, nonstructural projects need more local acceptance and cooperation. They have to be tailored to fit the local situation or they will not be implemented.

Third, the role of the local elected official will become more important. The elected official is the one who will have to find money and convince people before a project can proceed. We must remember that local elected officials do not care about floodplain management, they care about their town. If they see that a flood protection project will support their community goals, they will work for that project. If it ignores local politics, the project will not happen.

We must recognize that every local project is brand new to each community. It may be the twentieth relocation project for us, but it is a brand new experiment for them. We are going to have to have the patience to explain the project to elected officials and property owners and to modify it to fit the local situation.

Finally, floodplain management information will become more important.
variety of nonstructural solutions and the variety of situations where they have been
tried have resulted in a great number of reports. There are numerous federal and
state programs, each with its own set of rules. Cooperative efforts require the
presence of at least one person who knows what he or she is talking about and can
convince people. All of these things indicate that, in the future, information is
going to be much more important in our jobs.

Future Floodplain Managers

How about the person who is going to implement these programs in the future—the
floodplain manager? How can we be ready for the future? First we must be tech-
nically qualified. However, much of what we do from day to day was not and is not
taught in a course in school. Most of us are products of on-the-job training.
Therefore, we must not only be smart but also willing to learn.

The future manager must be anti-bureaucratic, anti-totalitarian and willing to
explain to everyone why things should be done in a certain way. We have to be
willing to share information and engage in mutual problem solving. We must be in
touch with other people who have access to information and work to keep up with new
developments in the field. We must be willing to try new techniques. We must be
concerned about people and sensitive to local politics.

I believe the employment status of floodplain managers will become less rele-
vant. With less money, the role of the federal and state governments will be
reduced. Participatory programs and mutual problem solving are dependent on people
having the right information; what agency a manager comes from is not important. A
good example of this is the Interagency Hazard Mitigation Team. There, the person
with the expertise is the one who influences the final report.

The future floodplain manager will become more dependent upon the professional
association. By providing conferences, newsletters, research projects, networking
opportunities, and (hopefully) a resource center, the professional association is the
best source of continuing information. However, we should remember that the associa-
tion itself must also adjust to the future with increased involvement of local
officials and floodplain residents.

Although the ASFPM conference is titled "Strengthening Local Flood Protection
Programs," in fact we have seen that it is the local floodplain managers who are
strengthening both our association and the nation's floodplain management programs.
They have the energy and the interest, and they will be accepting more and more of
the costs and responsibilities, for improving floodplain management. If we are willing to try new projects and listen to feedback from local officials and property owners, we will see even stronger programs that will help more people.
SPECIAL PUBLICATIONS

#2 Regulation of Flood Hazard Areas to Reduce Flood Losses, Volume 3
Jon Kusler. 1982. 300 pp. $8.00

#3 Strengthening State Floodplain Management, Appendix A to Volume 3
(SP #2). Patricia A. Bloomgren. 1982. 123 pp. $8.00

#4 Innovation in Local Floodplain Management, Appendix B to Volume 3
(SP #2). Jon Kusler. 1982. 262 pp. $8.00.

51 pp. $5.00.

#7 Preventing Coastal Flood Disasters: The Role of the States and Federal
Response. Proceedings of a National Symposium, Ocean City, Maryland,

#9 Improving the Effectiveness of Floodplain Management in Western State High-
Risk Areas: Alluvial Fans, Mudflows, Mud Floods. Proceedings of a Workshop,

#10 Evaluating the Effectiveness of Floodplain Management Techniques and
Community Programs. Proceedings of a Seminar, Washington, D.C., April 30-

#11 Managing High Risk Flood Areas: 1985 and Beyond. Proceedings of the Eighth
326 pp. $8.00.

#12 Flood Hazard Management in Government and the Private Sector. Proceedings of
the Ninth Annual Conference of the Association of State Floodplain Managers.
1986. 353 pp. $8.00.

#17 Summary of Major Natural Disaster Incidents in the U.S. 1965-85.
Claire B. Rubin et al. 1986. 45 pp. $4.00.

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#29 The Flood Breakers: Citizens Band Radio Use During the 1978 Flood in the

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#41 Community Recovery from a Major Disaster. Claire B. Rubin et al. 1985. 295 pp. $10.00.


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ANNUAL BIBLIOGRAPHIES
A Selected, Annotated Bibliography of Recent (1984-85) Natural Hazards Publications. David R. Morton. 1986. 103 pp. $7.00

TOPICAL BIBLIOGRAPHIES
#02 Bibliography of Flood Proofing. Anita Cochran. 1977. 9 pp. $1.00.

#03 Flash Flood Warning Bibliography. Kathleen Torres and Anita Cochran. 1977. 22 pp. $1.00.
