Improving the Flood Insurance Study Process (1983)

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The Committee on Flood Insurance Studies Research of the National Research Council's Advisory Board on the Built Environment reviewed the operation of the National Flood Insurance Program. It concluded that considerable progress has been made but that there exist many operational concerns related to the need for: (1) continuation of flood insurance studies and mapping in areas not yet studied, (2) restudy of areas previously studied, (3) improved flood insurance study products, and (4) more economical and efficient methods for the preparation of flood insurance studies and restudies.

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IMPROVING THE FLOOD INSURANCE STUDY PROCESS

Committee on Flood Insurance Studies Research

Advisory Board on the Built Environment

Commission on Sociotechnical Systems

National Research Council

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This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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Inquiries concerning this report should be directed to the Executive Director, Advisory Board on the Built Environment, National Research Council, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

CONTENTS

ABSTRACT

The Committee on Flood Insurance Studies Research of the National Research Council's Advisory Board on the Built Environment reviewed the operation of the National Flood Insurance Program. It concluded that considerable progress has been made but that there exist many operational concerns related to the need for: (1) continuation of flood insurance studies and mapping in areas not yet studied, (2) restudy of areas previously studied, (3) improved flood insurance study products, and (4) more economical and efficient methods for the preparation of flood insurance studies and restudies. Specific recommendations are made, and the technical and scientific adequacy and legal defensibility of currently used and potentially useful methods for conducting flood insurance studies and restudies are assessed.

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Chapter 1
INTRODUCTION

1.1 Background

The National Flood Insurance Act of 1968 (as amended) charged the U.S. Department of Housing and Urban Development (HUD) to promote the public welfare by providing insurance protection against flood, both riverine and coastal, and mudslide losses. As a condition for subsidized insurance protection, local communities are required to develop and adopt sound land-use practices that minimize exposure of property to floods. The Secretary of HUD delegated responsibility for administration of the National Flood Insurance Program (NFIP) to the Federal Insurance Administration (FIA), which must identify flood-prone areas and establish risk zones for an estimated 20,400 communities throughout the nation.

The Flood Protection Act of 1973 directed the Secretary of HUD to accelerate the identification of risk zones in flood-prone and mudslide-prone areas in order to make known the degree of hazard within each zone at the earliest possible date. As currently conducted, these studies generally result in quality information, but each one requires about two years to complete and costs about $77,600.* The adverse impact of this costly and time-consuming process is considerable. A community does not have all the information it needs to plan and adopt other than minimum floodplain-management regulations until a FIS is completed and it remains in the emergency portion of the NFIP, which provides lower flood insurance coverage limits than the regular program and requires a substantial federal subsidy for insurance premiums. In addition, FISs are used in the development of floodplain-management plans that can affect property values, tax revenues, and a host of

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*If technical evaluation contractor (TEC) time and costs are included, the average cost is $93,600 (excluding the substantial costs of printing, distribution, and cost modifications) and the average time, about four years.

related issues. Because of this potential effect, the plans, and the FISs on which they are based, are sometimes subject to attack and criticism.

It was to address these problems that the HUD Office of Policy Development and Research (PDR) initiated a major research project to develop, test, and demonstrate less costly, faster, and technically authoritative methods of performing initial FISs and flood insurance restudies (FIRs). This project was limited to the riverine aspects of flooding. The magnitude and national impact of the NFIP are such that the results of this research must reflect coordinated input from all the involved agencies and professions and be widely accepted by these groups. Thus, HUD requested that the National Academy of Sciences, through its Advisory Board on the Built Environment (ABBE),* provide the Office of PDR with advice and guidance concerning the NFIP research "to ensure that the broadest possible range of scientific, technical, legal, and community viewpoints [would be] available as input to the research in a timely manner and to provide for the objective assessment of the research results in terms of HUD and community needs and national implications." After the study began the Academy was informed that the contract had been transferred to the Federal Emergency Management Agency (FEMA) and, although the contract was not modified to reflect this change, FEMA will be referred to as the sponsor in the remainder of this report.

1.2 Scope of the Study

A committee composed of experts in hydrology, hydraulics, statistics, modeling, water-resources and land planning, floodplain management, photogrammetry, finance and insurance, and the legal implications of flood insurance studies was appointed to conduct the study (see appendix B for biographical sketches of committee members) and was charged with seven tasks that paralleled tasks to be performed by FEMA's research contractor, Anderson-Nichols and Company, Inc. (ANCo). Specifically, the committee was to:

1. Review and advise on the FIS research work plan developed by FEMA's research contractor.
2. Advise and assist FEMA in identifying the critical and minimum federal, state, and local information needs that must be accommodated in FIS techniques and products if the NFIP and community floodplain-management programs are to succeed.
3. Advise concerning the FEMA research contractor's analysis of FIS and FIR methods that may reduce time and costs and improve effectiveness.
4. Advise concerning the FIS and FIR methods chosen for field testing and evaluation and the user's manual developed for these methods by FEMA's research contractor and advise and assist FEMA in developing the criteria and plan for field testing and evaluation.

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*Formerly the Building Research Advisory Board (BRAB).

5. Convene a workshop of recognized experts and interested and affected parties prior to the final selection of methods and procedures for field testing and evaluation to assess and critique the choices made and the testing and evaluation plan.

6. Review the testing and evaluation results and the revised user's manual developed by FEMA's research contractor and assess their impact on the validity and usefulness of the methods.

7. Review the final research report prepared by FEMA's research contractor to determine whether the improved methods for FISs and FIRs are technically and scientifically sound, meet the critical and minimum information needs of the NFIP and communities, and are legally defensible.

The committee was required to prepare three interim reports (one on task 1, one on tasks 2 and 3, and one on task 4) and a final report presenting its conclusions concerning "whether the improved [flood insurance study and restudy] methods are technically and scientifically acceptable, meet critical and minimum National Flood Insurance and community needs, and are legally defensible." Early in the study, however, the committee was informed that FEMA intended to terminate ANCo's work after the first three of six tasks were completed (i.e., after ANCo had analyzed FEMA and community needs that should be met by the NFIP, evaluated the methods currently used in the NFIP to identify flood-risk zones in riverine areas, and identified promising alternative methods and procedures for performing various work elements of FISs).* This decision effectively modified both the committee's scope of work by eliminating tasks 4, 5, and 6 and the contract reporting requirements by eliminating the interim report on task 4.

1.3 Conduct of the Study

The committee reviewed ANCo's work plan (Final Project Work Plan: Improved Methods for Performing Flood Insurance Studies and Restudies, February 16, 1979) and transmitted an interim letter report presenting its assessment in December 1979. During the course of the ANCo research, the committee met on a number of occasions with ANCo staff; reviewed preliminary reports on specific areas of concern; and offered suggestions concerning, among other things, various approaches to conduct of the research, the types and depth of information and data to be collected, methods of data analysis, and potential utilization of the research results.

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*The tasks eliminated were the formulation of specific methods and approaches for conducting FISs and FIRs that would increase their cost-effectivenss and usefulness and preparation of a user's manual, testing and evaluation of the new methods and procedures proposed in the user's manual, and preparation for a final report identifying the recommended methods and approaches for improving FISs and FIRs.

In late August 1980, the committee received the ANCo draft report on its work (Promising Methods and Procedures for Performing Riverine Flood Insurance Restudies, July 31, 1980). It reviewed that report and presented its detailed assessment in terms of general comments, user needs, technical considerations, and legal considerations in an interim letter report transmitted in April 1981. The committee then continued its deliberations and drafted this final report.

1.4 Organization of the Report

The committee's conclusions and recommendations are summarized in chapter 2. Chapter 3 documents the establishment and operation of the NFIP to date and is included to provide the general reader with a historical frame of reference. Chapters 4 through 8 present the support for and elaborate on the committee's conclusions and recommendations.

Chapter 2
SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

Responsibility for identifying and mapping the nation's riverine and coastal flood hazard-areas rests with the National Flood Insurance Program and involves one of the most ambitious engineering and mapping efforts in the nation's history. To date, FISs have been initiated for approximately 10,000 communities and approximately 7,100 have been completed. About 7,000 communities now participate (some without detailed studies) in the regular portion of the NFIP in which local management and regulation of flood-hazard areas are mandatory. The communities in the regular NFIP account for the entire portion of flood-hazard-area residents who are eligible for full levels of insurance coverage under the NFIP.

Despite the progress cited above, the program presents many operating concerns. The demand for flood insurance restudies is growing due to land-use or other changes that affect the previously determined flood levels and study boundaries. Program costs have accelerated and program managers are seeking more cost-effective methods of preparing FISs and FIRs. Recent Executive Orders, both programmatic and reorganizational, present the possible need to expand the functions to be served by the FIS and FIR process. Committee observations and conclusions relating to these and associated issues are summarized below and discussed in detail in the several chapters of the report.

2.1 Flood Insurance Studies and Restudies

Present flood insurance studies are intended to serve two major purposes: Purpose 1 requires identification of areas and zoning within those areas subject to the 100-year flood (base flood) wherein flood insurance must be purchased if property owners are to qualify for federal and federally related financial assistance. The critical and minimum needs of purpose 1 are adequately fulfilled by present FIS procedures. Purpose 2 requires delineation of the floodway and floodway fringe wherein floodplain-management measures must be implemented. The floodway is the regular channel of the stream plus any adjacent areas that must be kept free of encroachment in order that the 100-year flood can continue to be carried without substantial increase in height. The floodway fringe is the remainder of the 100-year (base

flood) floodplain and is subjected to less stringent regulation. In many instances technical delineation of the boundary between the floodway and floodway fringe is difficult and costly. Study costs could be reduced and more effective floodplain management could be achieved if the floodway delineation were dropped and the more stringent floodplain-management regulations extended to the entire 100-year floodplain.

The effectiveness of the floodplain-management efforts also would be enhanced if the current practice of limiting FISs to individual and municipal boundaries was modified. Specifically, future FISs and FIRs should utilize a regional approach to the maximum extent feasible and multicommunity maps should be prepared when two or more communities share jurisdiction over a common floodplain.

FISs could be designed to serve additional needs ranging from technical assistance for local floodplain-management efforts to numerous aspects of the integrated multihazard management responsibility now assigned to FEMA. The exact nature of these needs can and should vary appreciably from community to community. The FIS process should be flexible enough to go beyond the minimum requirements of the NFIP in response to needs developed by the community but in accord with some basic cost-sharing guidelines. The most direct way to achieve the latter would be for FEMA to articulate a new program concept statement that explicitly identifies the responsibilities of federal and non-federal entities.

2.2 Hydrologic and Hydraulic Considerations

The hydrologic and hydraulic methodologies presently used in the preparation of a FIS are technically adequate and legally defensible in that they reflect generally accepted engineering practice. However, the cost-effectiveness of this portion of the FIS process could be improved in selected situations.

Under present procedures hydraulic analysis costs five times as much as the hydrologic analysis; yet, sensitivity analysis indicates that the hydrologic determination of flow rate is the most significant input factor contributing to total elevation error. Accordingly, efforts to seek undue refinement in costly field and office hydraulic studies may constitute a waste of resources in the absence of adequate hydrologic analysis. More emphasis on hydrologic analysis and less emphasis on hydraulic refinements often would be appropriate. Moreover, hydrologic analysis performed on a river-basin or regional basis would enhance both the consistency and cost-effectiveness of multicommunity studies.

Additional economies appear possible if study guidelines provided for more flexibility in selecting the level of analytical detail required. The present interpretation that essentially only one level of detail is acceptable for establishing flood elevations can be demonstrably in error if consideration is given to the adequacy of available data and the nature of the flood threat posed.

The growing demand for FIRs necessarily focuses attention on the need to have access to background data developed in the preparation of

the initial FIS. The cost-effectiveness of the FIR effort will be enhanced significantly if steps are taken to prevent the loss or physical deterioration of the FIS data.

2.3 Mapping Technology and Dissemination

Mapping methods currently used in the FIS process are technically and scientifically adequate and legally defensible.

Program cost-effectiveness would be improved if the FIS study guidelines and specifications clarified the conditions for which the vertical error tolerance of ±0.5 foot is required. Cost-effectiveness also would be improved if the guidelines provided for greater flexibility in choice of methods used to present results, including digital data bases and the use of photographs.

FEMA should experiment with and, where shown to be cost effective, adopt new surveying and positioning systems. The latter include inertial positioning, satellite Doppler, analytical photogrammetry, and, possibly, airborne profiling of terrain systems. These methodologies have potential for use both in the FIS process and in other disaster-related programs.

2.4 Judicial Review of FISs

The courts generally will uphold "good faith efforts" to manage floodplains based on the best available information. The presumption of validity of local legislative actions is applied to the floodplain-management regulations as to other land-use regulations under the police power of the state. Although most judicial opinions on floodplain regulations have involved evidence of recent, damaging flooding, it appears that the courts will uphold regulations based on 100-year-floodplain estimates that include areas outside the "floodplain of record."

Courts are sympathetic to the administrative problems posed by the cost and complexity of preparing detailed FISs and floodplain maps. As in other areas of regulation involving technical measurements, courts are willing to apply a principle of administrative necessity to uphold regulations based on studies appropriate in detail and cost to the degree of flood potential in the community and to the resources available. These judicial recognitions indicate that simplified and less expensive technical methods would be acceptable if applied for valid administrative reasons and if provision for variance in the event of outright mistake or hardship is ensured.

2.5 Problem-Oriented Research Needs

FEMA should establish a standing committee of experts to advise concerning technical issues on an as-needed basis and to assist in the formulation of problem-oriented research efforts. Several examples of the latter are cited in chapter 8 under the headings of technical issues, intergovernmental issues, and financial issues.

Chapter 3
THE NATIONAL FLOOD INSURANCE PROGRAM

3.1 Intent of the Framers

Given the lack of private insurance coverage against flood losses, public consideration of the possible need for a national flood insurance program began in the early 1950s. In 1956 Congress adopted a national flood insurance act but subsequently abandoned it. Efforts to revive the concept began in the early 1960s and a directive in the Southeastern Hurricane Disaster Relief Act of 1965 charged HUD to prepare a feasibility study on flood insurance. At about the same time, the Bureau of the Budget commissioned a special task force to review all aspects of national flood policy. The results of these activities were submitted to Congress in late 1966, and the establishment of a national flood insurance program was recommended but with important qualifications.

The report on the HUD effort, Insurance and Other Programs for Financial Assistance to Flood Victims (U.S. Senate 1966), recommended establishment of a dual-purpose national flood insurance program to spread the costs of financial assistance* to flood victims among all occupants of flood-hazard areas and to help prevent unwise use of land where flood damages would increase in the future. The report stressed the importance of limiting future growth in floodplains by using actuarial rates to charge floodplain occupants a premium consistent with the risk inherent in their location and by providing "incentives for state and local governments to practice wise management of flood-prone areas." Application of these approaches (actuarial rates and floodplain management), according to the report, would require detailed and accurate studies of hydrologic risk within each flood-hazard area. Discussed at some length in the report is the relationship between the statistical probability of flooding at a particular site and the

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*However, the report admitted that rates might have to be subsidized by the federal government for existing buildings in order to attract widespread participation.

dollar cost of average annual flood damage. A determination of this relationship was considered to be crucial in both the setting of actuarial rates and the adoption of floodplain-management measures. Thus, detailed flood-risk mapping of all areas where flood insurance would be offered was envisioned.

The report on the Bureau of the Budget effort, A Unified National Program for Managing Flood Losses (U.S. House of Representatives 1966), considered the feasibility of flood insurance as one of many possible public adjustments to floods. This report was even more cautious regarding the danger of unwarranted floodplain encroachment than the report on the HUD effort:

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

It also identified floodplain management as critical to a national flood insurance program:

> Planning and coordinating the development of the flood plain is required as part of any significant effort to break the pattern being fostered by present federal policies concerning flood damage prevention, namely the continuing sequence of losses, protection, and more losses. This requires leadership of the federal government in a fashion that will gain effective participation by the state and local governments. Although the federal agencies can exercise direct control over federal installations in the flood plain, the far greater number of decisions affecting new development are made by private individuals and corporations within the limits set by state and local plans and regulations.

This theme was repeated by Robert C. Wood, Undersecretary of Housing and Urban Development, at committee hearings on the proposed program (U.S. House of Representatives 1967):

> It would not be logical as a matter of public policy to permit insurance to be made available in localities which did not, on their own initiative or on the initiative of state or local authorities, take whatever steps would be appropriate to assure that their citizens would not unknowingly acquire and develop property where it is subject to known flood hazards.

3.2 Statutory Authority

The National Flood Insurance Act of 1968 reflects the intent of the framers to incorporate floodplain management and actuarial rates into the national program. With respect to insurance rates, section 1307 authorizes the Secretary of HUD to "undertake and carry out such studies and investigations...as may be necessary to estimate...risk premium rates for flood insurance...based on consideration of the risk involved and accepted actuarial principles...." Section 1308 however, authorizes the charging of rates less than actuarial "where necessary." According to the legislative history, Congress intended that rates "be reasonable and...encourage persons to purchase flood insurance." This has led to the establishment of a dual rate procedure involving subsidized rates for "existing construction" in the floodplain before a certain cutoff date and actuarial rates for new construction or "substantial improvements" made after the cutoff date. Significantly, the cutoff date between "existing" and "new" construction is related to publication of the FIS for each community. This policy is justified on the ground that actuarial rates cannot be calculated until a FIS is prepared. However, in practice this has extended, almost indefinitely in some cases, the definition of "existing construction" so that much development in floodplains since the advent of the NFIP has qualified for subsidized insurance rates.

As for floodplain management, section 1360 of the Act authorizes the Secretary of HUD to "identify and publish information with respect to all flood-prone areas, including coastal areas located in the United States, which have special flood hazards, within five years following...this Act, and establish flood-risk zones in all such areas... within fifteen years following such date." This section led to the development of a two-stage program involving the preparation of flood-hazard boundary maps (FHBMs) for all identified flood-prone communities (approximately 20,400) first and then the preparation of detailed FISs and flood insurance rate maps (FIRMs). (The second stage now is under way.)

Section 1361 of the Act authorizes the establishment of "criteria for land management and use" in floodplains and directs the Secretary of HUD (now the Director of FEMA):

> ...to carry out studies and investigations...with respect to the adequacy of state and local measures in flood-prone areas as to land management and use, flood control, flood zoning and flood damage prevention, and...develop comprehensive criteria designed to encourage, where necessary, the adoption of adequate state and local measures which, to the maximum extent feasible, will...constrict the development of land which is exposed to flood damage where appropriate, guide the development of proposed construction away from locations which are threatened by flood hazards, assist in reducing damage caused by floods, and otherwise improve the long-range land management and use of flood-prone areas, and...provide any necessary technical assistance to state, interstate, and local governmental agencies, to encourage the application of such criteria and the adoption and enforcement of such measures.

It is highly significant that the preparation of floodplain maps and studies (section 1360) is treated separately from floodplain management (section 1361). Congress obviously intended that floodplain management should be pursued regardless of the status of detailed FISs; therefore, it appears that the task of promoting floodplain management need not be tied to the time schedule or priorities of the mapping and FIS program.

3.3 Mid-Course Corrections

The first year of the NFIP was not encouraging; only four communities entered the program and only twenty policies were sold. Two obstacles to effective implementation of the program were identified. First, many communities did not have detailed flood insurance studies or floodplain maps on which to base regulations. Second, many communities were unwilling to adopt floodplain regulations voluntarily due to concern about limiting investment and hindering growth of the local tax base. These two obstacles were addressed in subsequent legislation in 1969 and 1973.

3.3.1 Emergency Program

Congress amended the National Flood Insurance Act in 1969 to temporarily waive the requirement for application of actuarial rates:

> ...for the purpose of providing flood insurance coverage at the earliest possible time, the Secretary...shall provide insurance coverage without regard to any estimated risk premium rates which would otherwise be determined under section 1307.

This authority established the emergency phase of the NFIP that provides for communities to participate in the program with application of only minimum floodplain-management criteria, pending completion of their flood insurance studies and rate maps, and for property owners in those communities to purchase limited flood insurance coverage. A community need acknowledge only that it has a flood problem and agree to enforce minimum flood-mitigation policies. Similarly, actuarial rates are not applicable even for new construction since they cannot be determined in the absence of a flood insurance rate map, and a limited level of coverage is provided for any structure at rates subsidized by the federal government.

Although it is true that actuarial rates cannot be applied if there are no FISs on which to base them, there appears to have been no need to excuse communities from adopting comprehensive floodplain-management regulations when floodplain maps and data were available from sources other than the FIA. Thus, the emergency program phase of the NFIP appears to have reversed the initial intent of Congress and tended to ignore the warnings in the reports on the HUD and Bureau of the Budget studies (U.S. Senate 1966, U.S. House of Representatives 1966) that development in floodplains not be encouraged.

3.3.2 Flood Disaster Protection Act of 1973

Major flooding in 1972 (resulting from Hurricane Agnes and the Rapid City flash flood) brought to Congressional attention the fact that flood insurance still was not widely in effect. Accordingly, the Flood Disaster Protection Act of 1973 placed the NFIP on a new footing. It required flood insurance to be obtained by any property owner in an identified flood-hazard area as a condition to receiving any federal or federally related financial assistance for purchase or development of such property and denied disaster assistance by any federal agency in communities not participating in NFIP. This reduced tremendously the marketability of flood-prone property in communities not participating in the NFIP and of property in a participating community for which the owner did not purchase the flood insurance.

A tremendous increase in NFIP activity (Table 1) resulted. The number of participating communities increased from about 2,200 at the end of FY 1973 to almost 17,000 by November 1980. The number of policies in effect increased from about 275,000 to almost 2 million while total coverage increased from $4.6 billion to $85 billion by December 1980 and to over $100 billion as of November 1981.

The areal diversification of this risk coverage, however, is far from uniform. As shown in Figure 1, almost 40 percent of the policies are concentrated in the low coastal areas in the southeastern section of the country that include only 0.4 percent of the participating communities.

The Flood Disaster Protection Act of 1973 thus generated a vast increase in the insurance activity of the program. Most of this coverage, however, has been issued at subsidized rates under the emergency program. As of April 23, 1980, out of approximately 1.8 million policies, only 50,500 were based on actuarial rates. This reflects, in part, the slow pace of completion of the FISs on which such rates can be based. As of March 1981, there were over 230,335 policies written at actuarial rates based on elevation and average risk zone rates.

3.3.3 Reclassification and Technical Assistance

Under the Carter Administration, the NFIP's resources were refocused to concentrate on the needs of the most flood-prone communities. A reclassification of a large number of communities was proposed that would limit FIS efforts to only seriously flood-prone communities and that would concentrate floodplain-management technical assistance efforts on these communities (Jimenez 1979). The process for accomplishing this was set forth in a memorandum from the Director of FEMA (Macy 1980). States were to recommend for reclassification communities having minimal flood hazard or development in floodplains. Flood insurance then would be made available in those communities at regular program levels of coverage but at a rate applicable to "unnumbered A zones" (equivalent to the emergency phase flat rate of $0.25 per $100 valuation). The intent of this proposed policy was to release staff and funds for the provision of improved technical assistance on floodplain management to communities with greater flood potential. Although various nonfederal interests have objected to this change in policy,

TABLE 1 National Flood Insurance Program, 1971-80

Year	Premiums ($1000)	Loss Payments ($1000)	Participating Communities	Policies in Effect	Coverage ($billion)
Fiscal					
1971	$ 6,341	$ 251	158	75,864	$1.1
1972	7,003	2,500	637	95,123	1.5
1973	15,315	15,007	2,271	272,448	4.6
1974	25,777	36,638	4,090	385,478	8.4
1975	40,950	26,235	9,625	539,888	13.7
1976	57,524	81,359	14,502	793,779	22.7
1977	83,783	59,190	15,585	1.1 million	33.6
1978[a]	40,235	50,887	16,000+	1.2 million	37.1
Calendar					
1978	99,456	135,568	16,000+	1.3 million	NA
1979	117,069	482,375	16,488[b]	1.6 million	60
1980	NA	NA	16,957[c]	2 million+	85

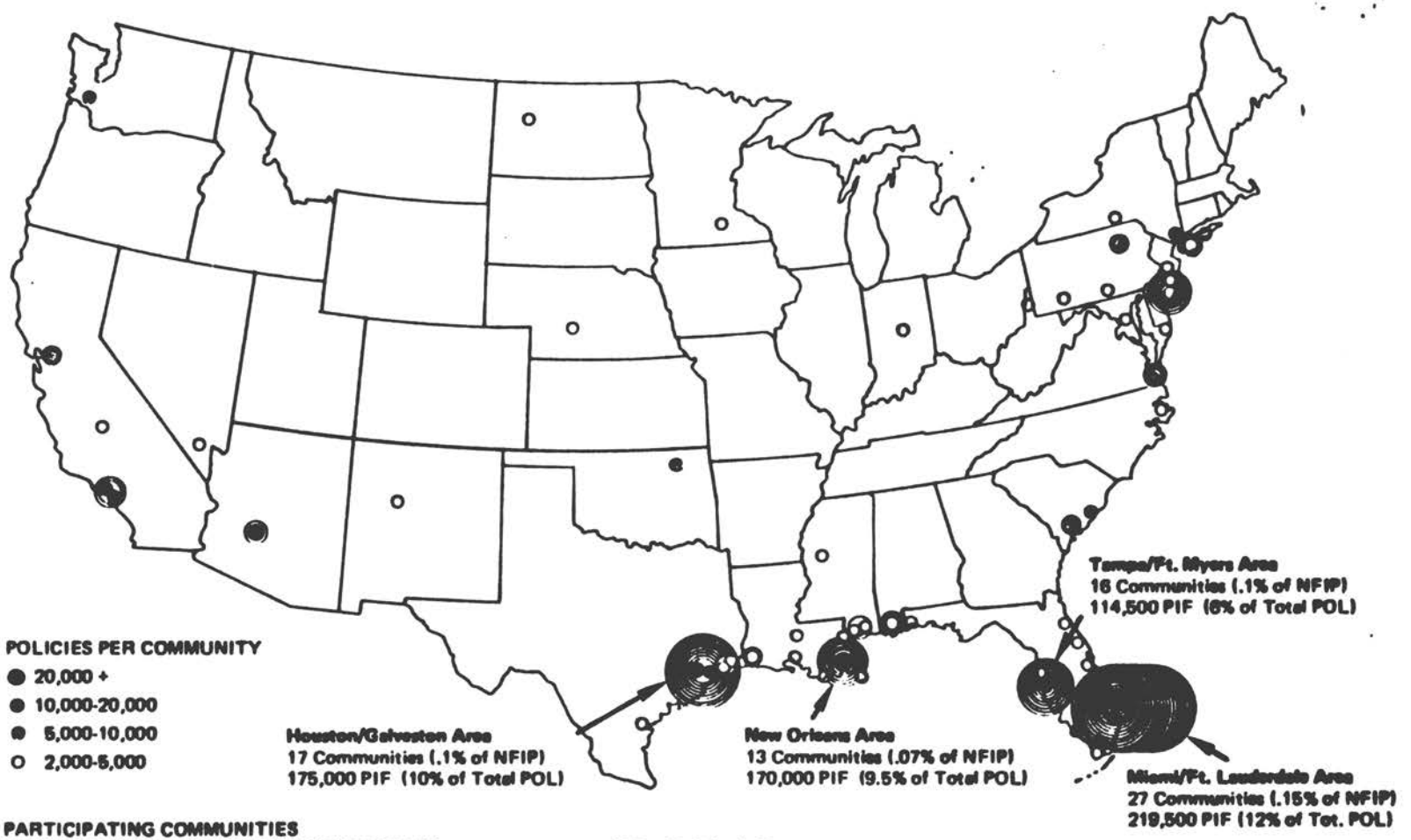
NOTE: Based on data provided by FEMA. NA means the information was not available.

[a] July 1 - December 31, 1977

[b] As of July 11, 1979. This figure includes 3,381 communities in the regular program and 13,107 in the emergency program.

[c] As of November 15, 1980, including 5,571 in the regular program and 11,386 in the emergency program.

FIGURE 1 150 top ranking communities in the NFIP plotted by policy count. In the 4 areas described in detail, 73 communities, which represent only 0.4 percent of total communities in the NFIP, have 2,000 or more policies each; the total number of policies in these areas is 679,500, which represents 38 percent of total NFIP policies.



it appears likely that some reclassification will occur. Nevertheless, the need for FISs of some communities will remain and less costly and less time-consuming procedures still will be required.

3.4 Current Status of the NFIP

The NFIP clearly is in a state of rapid growth and flux. The total number of participating communities has leveled off at about 17,100, but the ratio between regular and emergency program communities is changing rapidly. As noted above, the number of policies and total insurance coverage stood at 2 million and $85 billion, respectively, in December 1980, with a prospect of continued rapid growth. In 1979, revenue to the NFIP in the form of flood insurance premiums reached $117 million and loss payments totaled $482 million (Table 1) or more than half of the total NFIP insurance payments made through that year.

Progress in the preparation of FISs is shown in Table 2. By late 1981, 9,852 studies (excluding studies concerned with wave heights) had been initiated, and 7,093 completed. The communities studied include a substantial proportion of local government units with serious flood problems and population at risk. Total federal expenditures for the preparation of FISs have amounted to about $500,000,000 over the life of the NFIP. Of mounting concern to FEMA is the rising average cost per study (and per community) which now stands at about $77,600* or almost three times the cost in 1978. The problem of rising study costs and the need to study communities of comparatively smaller flood damage potential has prompted FEMA to seek more cost-effective methods of preparing legally defensible FISs.

3.5 References

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Macy, John W., Jr., Implementation of the NFIP's Accelerated Conversion Process, memorandum to regional directors, Federal Emergency Management Agency, October 17, 1980.

U.S. House of Representatives, A Unified National Program for Managing Flood Losses, House Doc. 465, 89th Cong., 2d Sess., 1966.

_____, Committee on Banking and Currency, Subcommittee on Housing, Hearings on the National Flood Insurance Act of 1967, 90th Cong., 1st Sess., 1967.

U.S. Senate, Committee on Banking and Currency, Insurance and Other Programs for Financial Assistance to Flood Victims, 89th Cong., 2d Sess., 1966.

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*As noted in Chapter 1, if technical evaluation contractor time and costs are included, the average cost is $93,600 (excluding printing, distribution, and cost modifications).

TABLE 2 Flood Insurance Studies: Number and Cost 1969-81

Fiscal Year	Number of Studies Initiated	Number Completed	Regular Program Communities with Elevations[a]	FIS Appropriation ($ million)	FIS Average Cost
1969-74	1,614		543	38.5	
1975	1,156	550[a]	0	46.2	43,800
1976 (TQ)	2,320	541	54	93.6	37,700
1977	1,474	1,088	569	75.0	27,400
1978	2,123	896	1,069	85.0	27,300
1979	791	1,413	860	85.0	39,700
1980	295	1,379	1,349	58.9	59,600
1981	79	1,226	1,430	48.4	77,600
TOTAL	9,852	7,093	5,874[b]	530.6	

NOTE: Based on data provided by the Federal Emergency Management Agency, November 1981.

[a] FY 1969-75.

[b] Includes effective FIRMs suspended and nonparticipating communities.

Chapter 4
FLOOD INSURANCE STUDIES AND RESTUDIES

The FIS and floodplain mapping program has proceeded in two phases. The first phase involved the preparation of flood-hazard boundary maps (FHBMs) that identify approximately those portions of each community which may experience flooding. The major purpose of these preliminary maps was to indicate which property within a community should be covered by flood insurance. Following enactment of the Disaster Protection Act of 1973, the FHBMs were used to identify the property that must be covered by insurance as a condition for approval of federal or federally related financing. These initial maps did not supply data adequate for comprehensive floodplain management or for the establishment of insurance rates, and in the mid-1970s the FIA focused most of its efforts on the preparation of flood insurance studies.

4.1 FIS Products

A FIS consists of a text and two kinds of maps: the flood insurance rate map (FIRM) and the flood boundary floodway (FBFW) map. The FIRM is the only official map identifying the regulatory base floodplain and elevations and is the only map prepared when no floodway is established. In addition to use in floodplain management, it is used by lenders to determine whether a property is in the floodplain and whether the mandatory flood insurance purchase requirement is to apply and by insurance agents to determine the rate zone of a property. The FBFW map is used primarily by the community as the basis of its floodplain-management program. The engineering work used to determine the hydrology and hydraulics is the same for both maps but there are differences in the way the data are displayed.

4.1.1 The FIRM

Development of a FIRM starts with determination of flood elevations and the establishment of flood-hazard factors (FHFs). The FHF is used to determine the flood-insurance zone classification and is, in fact, the device that correlates flood-risk information with insurance rates. The FHF for a reach is the average weighted difference between the 10-year and the 100-year floodwater surface elevations expressed to the nearest 0.5 foot and is presented as a three-digit code (e.g., if the

average difference between the 10- and 100-year floods is 0.4 foot, the FHF is 005; for a 0.8-foot difference, the FHF is 010 and for a 4.0-foot difference, the FHF is 040). When the difference between the 10- and 100-year elevations is greater than 10 feet, the accuracy of the FHF is to the nearest foot.

After the FHFs have been determined for all reaches, the entire study area is divided into flood insurance zones in accordance with the FHF determination. The zonal designations currently utilized are as follows:

Zone Symbol	Category
A	Area of special flood hazards and without base flood elevations determined.
A1-A30	Area of special flood hazards with base flood elevations. Zones are assigned according to FHFs.
AH	Area of special flood hazards that have shallow flood depths (from 1 to 3 feet) where base flood elevations are only slowly varying and can be established readily. Base flood elevations are shown on the FIRM.
AO	Area of special flood hazards that have shallow flood depths (from 1 to 3 feet) due to sheet flow. Base flood depths are shown on the FIRM.
A99	Area of special flood hazards where progress on a protection system (e.g., dikes, dams, levees) is deemed sufficient to consider it complete for insurance rating purposes.
V	Coastal high hazard area, with velocity, that is inundated by tidal floods. Base flood elevations have not yet been determined.
V1-V30	Coastal high hazard area, with velocity, that is inundated by tidal floods. Zones are assigned according to FHFs.
B	Area of moderate flood hazards.
D	Area of undetermined but possible flood hazards.
M	Area of special mudslide hazards.
N	Area of moderate mudslide hazards.
P	Area of undetermined but possible mudslide hazards.
C	Area of minimal mudslide hazards.

The zone designation and the elevation corresponding to the base flood (or 100-year flood) are presented on the FIRM. Only those areas within a community's land-use jurisdiction are displayed on the map. All streets within an identified special flood-hazard area and some major streets outside the area are named, but it has not been general practice to label other public facilities.

The legend of the FIRM gives a brief explanation of the zones, a key to the symbols used, the map scale, and a summary of previous map dates and reasons for previous map revision. A statement advises that the map is intended to be used for insurance purposes and that additional information is available from insurance agents or NFIP toll-free numbers.

4.1.2 The FBFW Map

The FBFW map is not mandated by the National Flood Insurance Act and is developed only in those cases when a regulatory floodway is developed. A key concept of floodplain management is the need to balance the future gain from floodplain development against the increase in flood hazard that would accompany development. The NFIP used the concept of a regulated floodway as a tool to assist local communities in this aspect of floodplain management. Implementation of this concept requires division of the 100-year-flood area into a floodway and a floodway fringe. The floodway is the regular channel of the stream plus any adjacent floodplain areas that must be kept free of encroachment in order that the 100-year flood can continue to be carried without substantial increase in height. The maximum increase allowed by the FIA is 1 foot unless hazardous velocities are produced with some lesser constriction. Some state and local provisions are more stringent. Encroachment outside the 100-year floodplain normally is not regulated.

The FBFW map identifies the areal extent of the floodway and floodway fringe areas. The locations of selected cross sections and map scales also are shown. The legend identifies the symbols used and advises the user to refer to the FIRM for identification of flood-hazard areas that were not studied by detailed methods.

4.1.3 The FIS Report

A FIS report typically is divided as follows:

1. Introduction--This section identifies the study purpose, the variety of agencies consulted in the development of the data, the authority under which the study was done, and the name of the contractor who performed the study.
2. Area Studied--This section identifies the reaches of streams studied by detailed and approximate methods and presents community descriptions containing physiographic and climatic information and a brief summary of flood problems and existing flood-protection measures.
3. Engineering Methods--This section describes in detail the methodologies used to determine the hydrologic and hydraulic parameters. For the hydrologic analyses, the resulting discharges are presented in tabular form. The hydraulic analyses establish flood elevations or profiles for the reaches studied in detail. A data table identifies base floodwater surface elevations; effects of floodway delineation on the base floodwater surface elevation; and the physical parameters of width, section area, and mean velocity of the delineated floodway. Data are entered in the table on the basis of cross-section location. These same locations are located on the profile so that the user easily can refer from the table to the profile (and vice versa) when making site-specific decisions as part of the floodplain-management regulatory process.
4. Floodplain-Management Applications--This section discusses the relationship between the various floodplain delineations and their regulatory implications. More restrictive state standards, if any, also are identified.

5. Insurance Applications--This section discusses the techniques used to relate the flood-hazard information to insurance zone and rating data.

6. Other Studies--This section references other published data sources (e.g., U.S. Geological Survey quadrangles, Corps of Engineers floodplain information reports, and other FISs) used by the study contractor and discusses the coordination process used to ensure consistent technical evaluation.

7. Location of Data--This section tells the user how the survey, hydrologic, hydraulic, and other pertinent data used in the study but not necessarily published can be obtained.

8. References and Bibliography--This section presents a complete listing of all maps, published studies, and other reports used by the contractor in the development of the FIS.

When the contractor has completed a preliminary draft of the FIS report, a public meeting, referred to as the final meeting, is scheduled by the regional FEMA staff to present the results to the community. (The contractor may have had an intermediate meeting with community and FEMA representatives in those states where certain technical standards, particularly the allowable rise for floodway encroachment, are more restrictive than the federal requirement.) At this meeting, representatives of FEMA, the contractor, and, in some cases, the state review the results of the study and discuss its implications in terms of insurance-purchase requirements and floodplain-management regulations.

Shortly after this final meeting, the proposed base flood elevations are published in the Federal Register and the community enters the 90-day appeals period. During this time the community, or individuals who so desire, may present technical data to refute the proposed base flood elevation. It must be emphasized that this right of appeal is established by statute and applies only to base flood elevations and not to the delineation of flood-hazard areas based on approximate methods. It also should be noted that appeals of the elevation can be entertained at any time in the future when they are supported by adequate technical evidence and certain administrative procedures are followed.

When the 90-day appeals period is over, any appeals made are considered and any revisions required are made accordingly. The proof draft of the study report then is sent to the community with a "letter of final determination" advising it that the study and maps will become effective in 6 months and that to convert to the regular phase of the NFIP and, thus, make additional insurance coverage available to community residents, it will be necessary to enact floodplain-management regulations meeting the minimum federal standards. The final base flood elevation and conversion data also are published in the Federal Register. When the community has 90 days left in the conversion period, a follow-up letter reminding it of the requirement to adopt adequate regulations and of the consequences of failing to do so is sent. When 30 days are left in the conversion period, the community is sent final notification of the requirements for converting to the regular phase and is told that it will be suspended if it fails to act.

This notice also is published in the Federal Register. On the conversion date, the community either converts to the regular phase if it has adopted suitable regulations or is suspended from the program.

4.2 Critical and Minimum Needs

Identification of critical and minimum federal, state, and local information needs (i.e., those needs that must be accommodated by and reflected in FIS techniques and products if the NFIP and community floodplain-management programs are to succeed) is complex given the degree to which the NFIP affects the flood-hazard-mitigation activities of federal, state, community, and private-sector groups. Thus, complete identification of these needs requires a review of the purposes of a FIS.

The National Flood Insurance Act (as amended) sets forth two separate but functionally interdependent objectives: the marketing of flood insurance and the implementation of floodplain management. Floodplain management, the more complex objective, includes regulation of development in the floodplain.

The effects of the NFIP were extended greatly in 1977 by Executive Order 11988, "Floodplain Management." The order directs all federal agencies to avoid actions in floodplains unless there is no practical alternative and directs federal agencies to utilize the NFIP criteria for identification of floodplains. This order has been supplemented by the U.S. Water Resources Council 1978 report on implementation of Executive Order 11988 and by the Council's (1979) presidentally endorsed report on a unified national program for floodplain management. The Executive Order and these reports have extended NFIP effects to other federal programs in that the Executive Order guidelines argue that any "critical actions" (i.e., those actions that, in the event of flooding, would result in catastrophic losses of lives and property) should be taken outside the 500-year floodplain as defined by the NFIP. Thus, the role of the NFIP has been expanded significantly beyond that of providing insurance and floodplain management for private implementation.

The potential for further expansion of the NFIP's role arose when FEMA was created to establish integrated multihazard management and the FIA was transferred to it. Also transferred to FEMA were the Federal Preparedness Agency (FPA) with responsibilities for federal flood warning, evacuation, and mitigation planning and the Federal Disaster Assistance Administration (FDAA) with responsibilities related to post-disaster assistance. The question necessarily arises as to whether or not the costly and detailed studies of the floodplain performed for the FIA program need to be broadened further to accommodate these other FEMA responsibilities.

On July 10, 1980, the Office of Management and Budget (OMB) issued a directive on nonstructural flood-protection measures and flood disaster recovery. On December 15, 1980, an interagency agreement was signed that defined the procedure to be followed to accomplish the elements of the directive and established hazard-mitigation teams. The implication of these actions for FISs and FIRs is that the federal establishment will be placing greater emphasis on technical assistance

and coordination among floodplain managers. Accordingly, FEMA is attempting to review the many needs that could be served by the FIS process.

Appendix A presents information prepared by ANCo (1980) that provides some indication of the potential breadth of this question. Undoubtedly a FIS procedure could be developed that would serve all the needs listed but, as ANCo (1980) correctly concluded, practical budgetary considerations would make it impossible "to satisfy every desire of every potential FIS user." A procedure that would reflect practical budgetary considerations as well as the information of potential users would be a cost-sharing mechanism whereby users would pay for the collection of additional data during the conduct of a FIS.

4.2.1 Insurance Marketing

The primary users of a FIS are those involved with the direct application of the insurance-marketing aspect of the NFIP. For various reasons the preparation and dissemination of FISs, despite a substantial federal investment, have incurred much criticism. The criticisms most frequently expressed by state and local users, not all of which are shared by the committee as subsequent discussion will indicate, include the following:

1. FISs are difficult to read and apply in practice. They involve the use of symbols and codes that require special training in order to understand and apply.
2. FISs are not readily available to the general public. They normally involve multiple sheets and this makes it difficult to post them in public places. They are graphically difficult to duplicate through photo copying. They are not distributed to property owners.
3. FISs are too restricted geographically. They are prepared on a strict community-by-community basis. This ignores the relationship between communities that share a floodplain or face each other across a stream.
4. FISs are not technically accurate. They frequently are based on inadequate hydrologic and hydraulic data. The methodology for translating such data into estimated flood-hazard areas frequently is challenged.
5. FISs do not provide enough information. For instance, they do not identify the location of critical public facilities or of structures that should be relocated. In short, they do not supply enough data for comprehensive land-use management in the floodplain.

The committee concurs with criticisms 1, 2, and 3 and recommends that FEMA take appropriate steps to improve the legibility, access, and geographic scope aspects of FISs. It disagrees with criticism 4 in that it believes the methodology to be technically accurate; however, it recommends that FEMA review more closely the work of the study contractors to ensure proper execution. Criticism 5 is principally concerned with the floodplain-management objectives of the program, and the committee believes it to be invalid because, as previously noted, it would be impossible to satisfy every desire of every potential user.

On the basis of its review, the committee believes that the minimum and critical needs for the insurance-marketing aspects of the NFIP necessarily include the following:

1. Delineation of the 10-, 100-, and 500-year-flood profiles.
2. Delineation of the 100- and 500-year floodplains.
3. Delineation of rate zones and corresponding base flood elevations.
4. Development of a methodology for relating the base flood elevation and the type of structure to a rate schedule.
5. Determination of the structural type of property.
6. Determination of the first-floor elevation of a structure.
7. Enactment of adequate local floodplain-management ordinances.

Current FIS procedures provide for all but items 5 and 6. At the present time, responsibility for determining individual structure elevation and/or structure type rests with the property owner and the insurance agent, and the committee sees no reason to recommend a change. The committee notes, however, that the enactment of a local floodplain-management ordinance does not ensure its forceful implementation. In fact, there is significant indication that local implementation of floodplain-management programs is often far from comprehensive.

4.2.2 Floodplain Management and Technical Assistance

The National Flood Insurance Act, Executive Order 11988, and the OMB all direct FEMA to provide technical assistance on floodplain management. The Act requires that technical assistance be provided to those communities that adopt the NFIP regulatory standards; the Executive Order states that federal agencies are subject to the same standards of the NFIP as participating communities; and the OMB directive underscores the importance of an integrated federal, state, and local approach to comprehensive flood-damage-reduction programs in both the pre- and post-flood contexts. Inherent in this emphasis on technical assistance is the realization that the success of floodplain management hinges on the ability (both technically and politically) of local units of government to adopt and enforce the requirements necessary to reduce future flood damage. Thus, the ultimate success of the nation's floodplain-management policies and programs will be a function of local interests and capabilities.

Although FEMA's resources (fiscal and personnel) are not adequate to meet completely floodplain-management and technical assistance needs, many of these needs could be met but are not because of administrative choices that have been made regarding the development and presentation of data. For example, an adequate flood-warning plan for a community would require hydrologic data for the entire contributing watershed but, at the present time, a typical FIS report presents only the hydrology for the area tributary to the reach within the community's boundaries. In the pre-flood context, stage hydrograph data (telling how long the water can be expected to be at flood stage for the regulatory or some other frequency flood) needed by local officials to make decisions regarding floodproofing of critical public

facilities are not presented in a FIS report although they very likely were developed by the study contractor. Similarly, the use of maps as a public educational tool in identifying potential flood-hazard areas has been prevented by administrative decisions concerning the content and graphics of FIS reports.

Thus, the present FIS report format could be significantly improved for the purposes of technical assistance and floodplain management. It is essential to reassess the guidelines and specifications for FISs (FIA 1979), floodplain-management regulations, and other administrative procedures (e.g., concerning distribution of studies and maps, and storage and retrieval of technical backup data) in an effort to revise the FIS report format, and the content as well if such is indicated, so that the reports will become better tools for all floodplain managers. The range of need, however, varies widely among communities. As noted above and in the previous section, budgetary and personnel limitations preclude FEMA from satisfying all local needs and the needs of all potential FIS users strictly through federal resources, and state and local governments should be called on to share the cost of particular elements of importance to them.

In addition, although the usefulness of FISs can be increased in a number of ways, several general policy issues are involved and should be considered. The following examples are presented only to illustrate the issues:

1. Flood situations create special emergency needs. Various transportation routes are blocked by different levels of flooding, and vital public services in the floodplain (e.g., electrical substations, transportation centers, and sewer, water, gas and communication utilities) can be affected. Similarly, institutional structures such as nursing homes, hospitals, clinics, and prisons create special emergency needs if located in a floodplain. Requirements of emergency plans to counteract these problems range from locating emergency water-treatment and power-generating facilities to finding temporary shelter for evacuees or storage space for movable property such as car dealer inventories. The policy issue to be resolved requires determination of the extent to which FISs should include evaluation of these emergency preparedness efforts and of the extent to which local communities should be required to incorporate the flood aspects of these considerations in their disaster planning efforts as a condition for participation in the subsidized insurance program.

2. Public acceptance and understanding of flood risk is important to acceptance and implementation of an effective floodplain-management program. Prominent markers displayed at equally prominent locations and depicting the elevation of historic and/or simulated flood levels are fundamental to this understanding. The broad distribution of basic city street maps that at least identify the approximate location of flood-hazard zones and that include a note indicating where more precise information can be examined also leads to public appreciation of the issue. In this context, a policy decision must be made concerning which needs should be filled by FEMA in the course of conducting a FIS and which should be filled by the community as part of the eligibility requirements for NFIP participation.

3. The mitigation of future flood losses is an important public policy goal. Pre-planning for the disaster-recovery stages is important to the effective operation of disaster-relief functions. In the case of flood disasters, critical questions arise concerning when a given structure, private or public, should be removed, elevated, and/or floodproofed rather than routinely rehabilitated and whether there are related considerations (e.g., waterfront rehabilitation). Pre-disaster planning obviously should influence these efforts, but a policy determination must be made concerning whether FEMA should attempt to fill this role in the development of a FIS or whether an ongoing disaster-planning effort should be part of the nonfederal eligibility requirements for community participation in the NFIP.

In summary, truly effective floodplain management can be achieved only when all levels of government are committed to the task. FEMA needs to establish procedures wherein FISs can be designed to go beyond the needs of the NFIP in response to needs articulated by the community but in accord with some basic cost-sharing guidelines. The most direct way to achieve this would be for FEMA to articulate a new program concept statement addressing the broad policy issues as well as specific technical issues. The issues raised during the discussion of floodplain-management user needs indicate that the concept statement needs to incorporate the following elements:

1. A statement of the flood insurance program, insurance marketing, and floodplain-management results desired by the years 2000, 1990, 1985, 1983, and 1982 expressed in terms of the nature and coverage of high-hazard properties and the nature and level of floodplain management;
2. A broad strategy for achieving these results including definition of the responsibilities of each of the parties involved in the program; and
3. A statement of the questions to be answered by explicit policy and procedural guidance. Without such a statement it is likely that modification of the FIS process will be incremental and not cost-effective.

The committee believes that thorough examination of the policy questions raised by the committee may well lead to more effective fulfillment of the overall FEMA mission as well as to a more responsible role for nonfederal entity participation in the NFIP and that preparation of such a program concept statement should receive the highest priority. In doing so, FEMA should ensure that a mechanism is developed to provide for consideration of as broad a range of viewpoints as possible.

4.3 The Need for a Basin-wide or Regional Perspective

FISs currently are conducted and published on the basis of individual government units--municipalities, counties, or other entities. This is totally at variance with the physical geography of the United States. Governmental and physical units seldom coincide and municipal boundaries shift frequently. The committee devoted much discussion to this conflict and concluded that FISs, and especially their hydrological elements, should reflect a basin-wide or regional perspective. The

following section presents a case history of the operation of the FIS process in a small watershed in Florida with multiple political jurisdictions. The more general problems of intergovernmental fragmentation and the need for basin-wide analysis then are discussed.

4.3.1 The Pinellas County Experience

Pinellas County, Florida, is the kind of community for which the NFIP exists. It is a rapidly urbanizing area subject to both coastal and riverine flooding. In the riverine parts of the county there is a recent history of severe flooding with a clear trend toward increasing frequency as urbanization progresses. The county population increased from 568,000 in 1970 to an estimated 791,000 in 1978. The overall riverine problem encompasses 52 watersheds and 24 political jurisdictions.

A large part of the current development is in unincorporated areas. The existing drainage system was subject to severe stress by 1978, and the county elected at that time to undertake a planning study for each drainage basin to develop a consistent set of drainage criteria. Three consulting firms contracted to provide the required services.

Prior to initiation of the county study, NFIP studies had been begun in several communities. It would seem logical that common objectives and tasks would mandate a close liaison between the county's consultants and the NFIP consultants, but when the county's consultants sought to discover what was being done in the NFIP studies, they could not obtain the information.

The first task in the county's study was the development of a uniform set of hydrologic assumptions and data to be used throughout the county. This was done to place the county's plan on a consistent technical footing. In addition, hydraulic calculations were carried out on a basin-wide basis. This procedure completely eliminated problems of reconciliation of technical results because the methodology of the study was fundamentally consistent.

The county formed a steering committee composed of representatives of each consulting firm and several county departments. Its purpose was to ensure uniformity in presentation and to select certain study parameters. For example, it was decided that storm runoff associated with the 5-, 10-, 25-, 50-, and 100-year storms should be analyzed. The group also coordinated study efforts with the various jurisdictions in the county. It permitted each consulting firm to use its own modeling approach, reasoning correctly that familiarity and experience with a technique, combined with sound professional judgment, was more important than the specific computer program used. However, each firm was required to validate its model with measured field data.

One area in the county, Joe's Creek Basin, is a good example of the study. Joe's Creek Basin is over 14 square miles in area (Figure 2) and includes some 30 miles of channels and major outfalls in the basin. The cities of St. Petersburg, Kenneth City, and Pinellas Park lie all or partly in the basin. The Pinellas Park Water Management District is responsible for some drainage facilities in the basin, and there are large unincorporated areas. The need for a coordinated drainage program is evident.

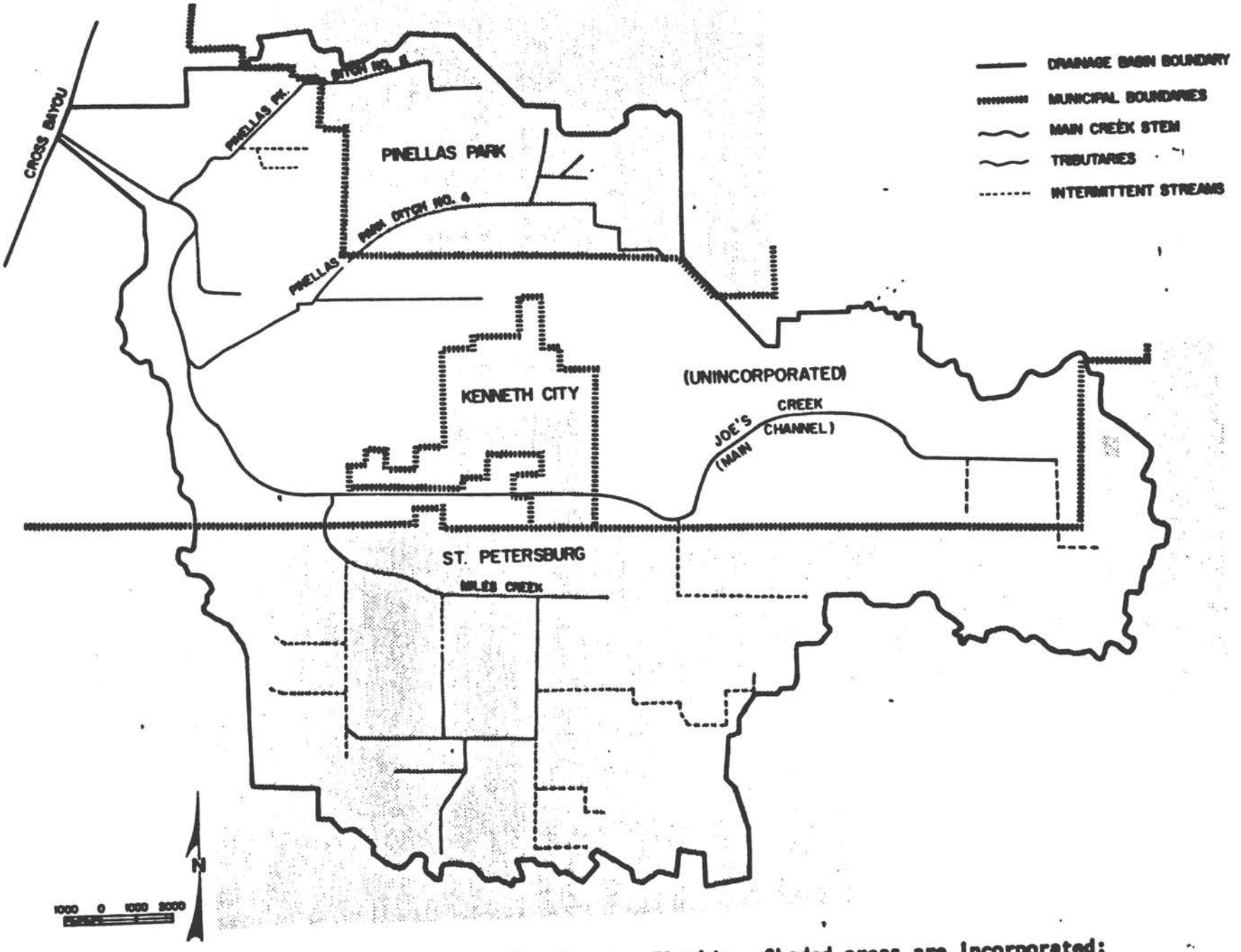

FIGURE 2 Joe's Creek Basin, Pinellas County, Florida. Shaded areas are incorporated; corporate limits are generalized outside the basin.

The county's study of Joe's Creek Basin began in November 1978 and was completed in December 1979 at a total cost of about $70,000. The study included location of the flood elevations for each of the storms listed above. It also contained a detailed evaluation of six alternative plans for flood abatement and recommended $20.6 million in capital improvements. At the present time, about $1.6 million of these improvements have been built. Obviously, the county's study went well beyond the scope of a NFIP study even though it included all elements of the NFIP study.

Four contracts for NFIP restudies in the Joe's Creek Basin have been awarded--one for each political unit in the basin. Since they are based on political subdivisions, they include some areas outside the basin. The initial studies began in the early 1970s, and the current projects are the second or third round of restudies. These began in mid-1978, and as of April 1981, none had been released by FEMA even though most of the technical work was completed. The total estimated cost of the four studies is between $52,000 and $95,000. County personnel have indicated that no contacts have been initiated by NFIP contractors to obtain the results of the county's study. The status of reconciliation between the NFIP study areas is unknown.

The conclusions seem to be that NFIP studies are more costly than the county's study, that they take longer to complete, and that they are not well coordinated within a basin. This situation and others like it provide the basis for much of the criticism of the NFIP.

This case history highlights three major deficiences in the FIS process:

1. Failure to take advantage of existing or ongoing flood studies by other units of government.
2. Conduct of studies of individual muncipalities rather than of logical groups of communities (e.g., those sharing a small watershed or a floodplain), which results in multiple studies for the same area at much greater cost.
3. Delay in completion of studies, which defers the effective date of a community's adoption of floodplain-management regulations and its entry into the regular program.

4.3.2 Intergovernmental Considerations

The foregoing example highlights the fact that program cost and program timeliness are not solely functions of technical methodology. Equally important are the geographic orientation and the infrastructure or project organizational arrangements. This is especially true where intergovernmental considerations are a major issue.

The nation's floodplains reflect a mosaic of private and public jurisdictions that differ in geographic scale and legal authority while collectively sharing the benefits and burdens of being located next to water. These jurisdictions differ widely in their objectives, policies, and actions concerning floodplains, but each generally attempts to promote its own interests, often without regard for neighboring jurisdictions. Nevertheless, the very nature of rivers and streams dictates that the action or nonaction of one authority may affect neighboring areas for better or for worse. There are two readily

identifiable situations in which multigovernmental conflict may arise. The first involves rivers serving as political boundaries and the second, rivers and streams flowing across political boundaries from one jurisdiction into another.

Most inland streams of any significance serve as boundaries between jurisdictions. At the international scale, the United States faces Canada across rivers in Maine, New York, Michigan, and Minnesota, and it faces Mexico across the Rio Grande. Forty-one states are bordered in part by inland rivers or lakes. The total length of interstate river boundaries is estimated at about 12,000 miles (excluding meanders). Rivers that bound states necessarily also border smaller units of jurisdiction--counties, special districts, municipalities, and private property holdings. This role of inland streams as boundaries can cause cross-stream conflicts between jurisdictions. Where floods are concerned, one jurisdiction may permit improper storm-water drainage, filling, diking, or other forms of encroachment that may increase flooding in jurisdictions across the stream. Such an alteration of flood patterns may wreak havoc if one community has developed on or near the floodplain on its side, assuming from past flooding patterns that it will not be engulfed.

Streams that flow <u>through</u> political jurisdictions also can cause conflicts--these of an upstream-downstream nature. A major problem of this type in small watersheds is upstream development, which normally raises flood levels downstream. Another form of upstream-downstream conflict is the "bottleneck" (i.e., if jurisdictions on opposite sides of a stream both obstruct their floodplains through levees or other means, the resulting constriction causes backwater for areas immediately upstream).

The effects of multigovernmental fragmentation in floodplains are cumulative. Most watercourses of any significance involve both cross-stream and upstream-downstream conflicts. The cumulative effects of specific actions, however, are not always obvious because a flood may not occur for years. The multigovernmental implications of flooding too often are seen only in the aftermath of a flood. Certainly not all flood damage can be blamed on the actions of neighboring areas but, just as certainly, even the most responsible floodplain-management unit is to some extent at the mercy of its neighbors. Ultimately, there is a need for multigovernmental arrangements to promote mutually responsible and enforceable floodplain-management policies.

Floodplain management is just one of many public concerns that transcend political boundaries. Much has been written about techniques for "intergovernmental coordination." (See particularly reports of the Advisory Commission on Intergovernmental Relations.) Much of this literature, however, deals with "vertical" relationships among federal, state, and local entities. Although that dimension is important to floodplain management, the emphasis here is on "horizontal" cooperation among adjoining units of government--thus, the use here of the term "multigovernmental coordination." Techniques to be considered include interstate compacts; comprehensive river-basin planning; statewide regulations; county, special district, and intergovernmental agreements; extraterritorial powers; and litigation.

The organization and implementation of FISs must take into account the multigovernmental realities of a given area. Where multigovernmental issues are important, hydrologic studies should be undertaken regionally (on a watershed basis if possible) and should not be limited to a single jurisdiction. Similarly, the determination of floodway dimensions should be based on analysis of the entire floodway, and multicommunity maps should be prepared for groups of communities that share jurisdiction over a common floodplain.

In particular, the committee believes most strongly that future FISs and FIRs should be based on a regional analysis. Use of a regional or watershed basis for analysis will yield several benefits. With respect to mapping, data-base costs will be reduced and the consistency and accuracy of the results will be improved. In addition, a change of community boundaries will not require remapping or added mapping. Further, regional hydrologic analysis will reduce cost and increase consistency, and the gain in consistency will generate further reductions in cost by reducing the need for justification of boundaries between communities and for restudies.

4.4 References

Anderson-Nichols and Company, Inc., Promising Methods and Procedures for Performing Riverine Flood Insurance Restudies, ANCo, 1980.

Flood Insurance Administration, Flood Insurance Study Guidelines and Specifications for Study Contractors, U.S. Department of Housing and Urban Development, Washington, D.C., 1979.

Chapter 5
HYDROLOGIC AND HYDRAULIC CONSIDERATIONS

The committee has concluded that the hydrologic and hydraulic methodologies currently used in the preparation of a FIS are technically adequate and legally defensible in that they reflect generally accepted engineering practice. The committee believes, however, that FEMA could improve the cost-effectiveness of the overall FIS process by:

1. Allocating more resources to hydrologic than to hydraulic studies,
2. Providing for more flexibility in the level of detail required,
3. Modifying field data requirements,
4. Developing improved methods for the storage and preservation of FIS background data,
5. Refining or discarding the "regulatory floodway" concept, and
6. Developing regional study methods.

5.1 Allocation of Cost Among FIS Components

The existing FIS methodology is quite standardized by the generalized Flood Insurance Study Guidelines and Specifications for Study Contractors (FIA 1979). The first step in the study process involves dividing the streams in a community into reaches and deciding which are to be studied by detailed methods and approximate methods and which are not to be studied at all. This subjective decision is made by FEMA in consultation with community representatives, the state coordinating agency, and the study contractor. Once this assignment is made, the contractor's activities are defined narrowly by the aforementioned guidelines.

ANCo (1980) reviewed cost data for numerous completed FIS contracts and presented the following average breakdown of cost by study component:

Component	Average Percent of FIS Cost
Reconnaissance	3.4
Approximate	3.5
Aerial survey	19.6
Land survey	19.3
Hydrology	6.2
Hydraulics	18.7
Profile concurrence	2.6
Work map materials	1.5
Work map preparation	7.7
Report preparation	7.8
Other	9.7
Total	100.0

Although the titles of most of these components are more or less self-explanatory, a few brief comments are appropriate. The reconnaissance task involves both historical review and present field identification of key hydrologic and hydraulic considerations. The so-called approximate component is really a verification and updating (modification) of the initial FHBM. The "other" category relates primarily to coordination activities--especially in reconciling hydraulic findings and in presenting of results.

It is useful to recognize that there are really three major tasks served by the eleven components listed above. These are hydrologic analysis, hydraulic analysis, and the presentation of results. The hydrologic analysis involves determining the magnitude of the rate of flow expected at selected frequencies of occurrence. The hydraulic analysis involves determining the flow elevation associated with the flow rates established in the hydrologic analysis. The presentation of results involves preparing the written explanation (report) and graphical material (maps and profiles) utilized to convey the results of the analyses. Table 3 presents a subjective but reasonable suballocation to these three tasks of the ANCo data. In round numbers, these suballocations indicate that hydrologic analysis accounts for 10 percent of the current cost of a FIS, that hydraulic analysis accounts for 50 percent, and that presentation of results accounts for 40 percent.

ANCo (1980) also explored the sensitivity of study results to errors in input data. This analysis indicated that the discharge variable (i.e., the hydrologic determination of flow rate) is the most significant input factor contributing to total elevation error. Moreover, the selection of the Manning "n" values used in the hydraulic calculations was the second most important or significant factor in contributing to total error. These findings imply that, in many cases, past study costs could have been reduced without significant loss of accuracy if fewer surveys of channel cross sections were used. Alternatively, more emphasis on hydrologic analysis and improved guidelines for selection of channel roughness coefficients, while reducing the number of surveyed field cross sections, might have resulted in either more accurate results or lower total costs at no significant sacrifice in the accuracy of profile determinations. Whether these same

TABLE 3 Distribution of Costs Associated with the Conduct of FISs

Study Component	Percent of Total FIS Cost	Percent Allocated to Hydrologic Analysis	Percent Allocated to Hydraulic Analysis	Percent Allocated to Presentation of Results
Reconnaissance	3.4	1.7	1.7	
Approximate	3.5		1.0	2.5
Aerial survey	19.6		9.8	9.8
Land survey	19.3		15.4	3.9
Hydrology	6.2	6.2		
Hydraulics	18.7		18.7	
Profile concurrence	2.6		2.6	
Work map materials	1.5			1.5
Work map preparation	7.7			7.7
Report	7.8			7.8
Other	9.7	2.0	2.9	4.8
Total	100.0	9.9	52.1	38.0

generalizations can be applied to future efforts, many of which will be devoted to restudy as contrasted to initial study, is an issue deserving of careful consideration.

5.2 Flexibility in Analytical Approach

Too little attention has been given to the importance of the initial subjective judgments whereby streams are divided into reaches to be studied by detailed methods or approximate methods. One major problem arises because the FIS guidelines (FIA 1979) give considerable attention to the methods of analysis for those areas selected for detailed study and almost no attention to the methods of analysis for those areas selected for approximate study.

The committee believes that the present division into approximate and detailed is too rigid. The implication of this division, and the interpretation to date, is that only one level of analytical detail is acceptable for establishing flood elevations. This is demonstrably in error if consideration is given to the adequacy of available data and the nature of the flood threat posed, both of which vary substantially from place to place. The point to be made is that a spectrum of level of detail required should be provided for in the FIS guidelines. The choice of level of analytical detail required in a specific case should be made by FEMA on the basis of cost-effectiveness criteria.

One factor in the determination of level of effort for a study should be a sensitivity analysis. Such an analysis need not be performed for each study; generalized results could be developed into a set of guidelines. Such an analysis should relate relative costs to the sensitivity of accuracy of study results to work element uncertainties. For example, for flood insurance purposes, sensitivity of study results is measured in terms of flood boundaries and delineation of

flood insurance rates. The necessary data are available for such an approach to determination of study detail. FEMA should develop or have developed for it a procedure based on cost-effectiveness criteria for the choice of level of study on a reach and community basis.

In short, the committee believes that approximate methods or less detailed methods are appropriate for certain areas and that those less detailed methods can be used to develop data sufficient to determine actuarial rates. At present, areas chosen for study by approximate methods are designated as unnumbered A zones and assigned a uniform, subsidized premium. The decision as to level of effort to be expended may be correct, based on the fact that such areas often are relatively undeveloped; however, subsidized rates encourage development, which may be an undesirable consequence of the floodplain-mapping program.

An example of where flexibility in methods of analysis could be of benefit is provided by those several thousand communities being considered for accelerated conversion from the emergency program to the regular program. The aim is commendable, but a simplified procedure should be developed that would yield studies with an accuracy sufficient for and commensurate with the communities concerned. It also would accelerate conversion of smaller communities, provide a basis for actuarial rates, and reduce costs for those studies. A procedure for implementing such an approach would be to:

1. Set criteria based on population at risk or property at risk and have such criteria reviewed at the state level. Modifications could be made on a state-by-state basis with concurrence of the appropriate state officials.
2. Apply the criteria and select the communities to be studied using the revised procedures.
3. Establish a revised set of guidelines for studies of such communities. A candidate set might be to allow use of U.S. Geological Survey (USGS) regional flood-frequency studies for determination of flood discharges; allow use of presently available USGS topographic maps or other presently available more detailed maps; and allow use of normal depth calculations for flood-profile delineation. The use of normal depth calculations would involve having the slope determined from a topographic map by distance between contour lines crossing the channel, having cross sections picked from contour crossing points plus interpolated elevation for main channel crossing, and using generalized values for Manning's coefficients (e.g., sand channels, 0.02; flat channels, not sand, 0.035; steep channels, not sand, 0.045; or some more refined breakdown that can be based on available office information).
4. Allow case-by-case appeal to refine the limits.

5.3 Field Data Requirements

The committee recognizes the need for field data to support the analytical portion of a FIS and believes that they should be factored into all modeling work when available or obtainable at reasonable cost. Nevertheless, the committee also believes that in many cases too large a fraction of the FIS budget has been spent on field data collection. This not only wastes valuable dollars but also can result in invalid computer runs.

Step-backwater methods, such as the HEC-2 model, can be overdetermined by too many data. The flow conditions that actually exist in a complex system cannot be treated exactly with a model such as HEC-2. Attempting to put too many cross sections, particularly frequent constrictions, in the model can result in a solution that is hydraulically invalid. In some cases less frequent cross sections will give a solution that is a better approximation of hydraulic reality. Thus, the committee believes that FEMA should rewrite its requirements for cross-section data to reflect the capabilities of the models used.

The FIS guidelines also should be revised to recognize that the complete execution of a computer model does not guarantee valid results. Proper guidelines could reduce field data requirements without reducing accuracy. The ANCo analysis (1980) indicated that it would be cost-effective to shift study efforts from hydraulic to hydrologic tasks, and this applies to field data as well as analytic activities.

There are times when the approach using step-backwater methods is not the best one. The committee discussion of legal defensibility issues (see chapter 7) concludes that the principle of administrative necessity permits the use of simplified methods of analysis. There are times when the use of normal depth cross sections, for example, can produce results as accurate as step-backwater methods or, if not as accurate, sufficiently accurate for a specific situation. In cases of this nature, the requisite field programs should reflect the level of sophistication of the analytic methods.

Sometimes it will be useful to use an approach more sophisticated than step-backwater methods. Such was the case in the Pinellas County example where the thrust of the study into flood-abatement alternatives mandated the use of dynamic hydraulic models. When this type of approach is used, field data requirements change. Models of this class must be calibrated against measured hydrographs. Thus, the program requires more flow data but not more cross-section data.

To summarize, present FIS field data requirements are too rigid and often are misinterpreted by study contractors. In general, too much effort is spent on cross-section data and too little attention is given to the particular analytic requirements of the individual case. Some flexibility in the approach used will prove to be cost-effective.

5.4 Data Storage

FISs generate considerable demographic and physical data describing communities, streams, and floodplain topography. Compilation of these data accounts for a significant portion of FIS costs. Model output yields another large block of data concerning the streamflows and resultant flood elevations. FIS reports generally do not include these data, but FIS contractors are required to keep the data for five years following study completion, unless FEMA asks for them earlier, and then to submit them to FEMA. Unfortunately, however, no standards exist for the way in which the data are to be stored during the five-year retention period and FEMA appears to have no formal system for their storage and retrieval. In addition, many studies were completed about five years ago and the data generated may be lost unless FEMA takes some action to preserve them. The shift in emphasis from original studies

to restudies will require that these data be available, and the cost to the nation of gathering these again would be immense. The committee therefore recommends that FEMA establish a central repository for all data generated in FISs. This will require the development of a formal filing and retrieval system. This system probably should not be computer based; what is needed is a simple storage system that will enable FEMA personnel or subsequent study contractors to easily retrieve and reproduce the final results of every study. FEMA also should develop new data storage standards for all data that study contractors are required to submit. These standards should be structured to prevent the loss or physical deterioration of FIS data and to provide for consistency in data format. With respect to studies already completed, FEMA should initiate an immediate effort to prevent the loss or physical deterioration of the data and should arrange to collect the material from study contractors if it has not already done so.

5.5 The Regulatory Floodway

The concept of the regulatory floodway has been selected by the committee to demonstrate the uneven integration of the technical, regulatory, and insurance aspects of the NFIP. The floodway is that portion of the floodplain that must be kept open to pass the amount of water that would be discharged in the 100-year-flood event. The remaining portion of the floodplain, the floodway fringe is the area in which development is allowed if certain minimum elevation and construction standards are met. The separation of the floodplain into floodway and floodway fringe is determined by an encroachment analysis. The extent of land designated for development or the limit of the floodway fringe is fixed by the amount that the water will be allowed to rise. Federal regulation establishes 1 foot as that limit.

Floodplain regulations must ensure that new construction in the floodway is severely restricted so that flood stages are not increased. Existing development becomes a nonconforming use and, if damaged by any cause to an extent greater than 50 percent of its value, cannot be rebuilt "as was" but must be rebuilt in conformance with the regulations. For the floodway fringe, new development and substantial improvements must be done in accordance with the provision of minimum first-floor elevation being the base flood elevation (the elevation of the 100-year flood). Unfortunately, the specific elevation is the unencroached elevation. Thus, the technical standards assume development in the floodplain that will cause the base flood elevation to be 1 foot higher but the regulations specifying first-floor elevation for new development do not account for this 1 foot rise. The technical standards also assume that bridges, culverts, and other construction stay open during the flood flow and do not consider the fact that debris or ice jams can clog these structures and raise flood stages appreciably. Given that such clogging can and does occur, many states and local governments add "freeboard" to their first-floor elevation requirements but there is no comparable requirement in the federal regulations.

Locating floodways on the ground may be a problem. Where the floodway alignment follows a definite physical feature such as a road, the boundary is readily ascertained. When this is not the case, there

is not sufficient information in the FIS to locate the floodway boundary. Local authorities estimate the boundaries by scaling from the map, inspecting the site, or using some other means. More detailed data defining the location of the floodway are developed during the study but are not presently included in FIS reports despite the fact that they would be of great value for floodplain management. Background data are not presented in the study and experience has shown that they are very difficult to obtain because FEMA has not established a data storage and retrieval system.

Structures in the floodplain of a participating community can be indemnified for flood damage by the purchase of flood insurance. The location of a structure with respect to the floodway has no bearing on insurability. If the structure is in the floodway and is severely damaged, its future insurability will be affected only if the community properly enforces its ordinance and denies the rebuilding permit. It is possible that the community might issue the permit and the building could be rehabilitated, reinsured, and flooded again in a future flood. Strict enforcement of ordinance provisions after a flood disaster is politically difficult. Quantified data concerning violations of this type are not available because there has not been adequate monitoring of community compliance. The FIA has been hesitant to suspend communities for not properly enforcing their ordinances but it could refuse to insure structures built or rehabilitated in violation of the ordinances. The FIA has the power to provide strong incentives for local compliance (including suspension, refusal to reinsure, and use of flood insurance policy money to relocate the property or floodproof it in accordance with ordinance provisions), but the application of these incentives has been uneven or nonexistent.

Determination of the floodway increases the cost of the study. There is some question as to whether anything really is gained by establishment of a regulatory floodway or whether the program would be more soundly based if floodway regulations were extended to the entire 100-year floodplain with opportunity for flexibility to alleviate hardship. The committee favors elimination of the floodway and application of restrictive floodplain-managment regulations to the entire 100-year zone.

5.6 Regional Study Methods

Regional analysis would be enhanced if a standard hydrologic method were used for determination of floods of the various frequencies. Such a method might include the following:

1. Adoption of USGS regional flood-frequency studies on a report-by-report basis, which will provide for a consistent level of product quality control. If a particular regional study were considered inadequate because of inadequate quality of work or because it was out of date, new analyses could be performed by FEMA or commissioned by FEMA to be done by the USGS or a private contractor.
2. Use of U.S. Water Resources Council (WRC) guidelines for gauged sites. Applicability of results should be discussed, however, and alternative analyses allowed where justified (e.g., for a basin where snow melt and summer thunderstorms cause a mixed distribution of annual flood peaks).

3. Adoption and issuance of criteria for combining station data with regional analyses.

4. Allowance of deviations from the adopted procedures only with justification. All requests for deviations should receive an independent review before allowance.

Although this procedure may seem rigid, it illustrates that guidelines for regional analysis that provide for consistent quality control can be adopted. Thus, the committee recommends that this or a similar procedure be adopted for regional hydrologic analysis.

5.7 References

Anderson-Nichols and Company, Inc., Promising Methods and Procedures for Performing Riverine Flood Insurance Restudies, ANCo, 1980.

Federal Insurance Administration, Flood Insurance Study Guidelines and Specifications for Study Contractors, U.S. Department of Housing and Urban Development, Washington, D.C., 1979.

Chapter 6
MAPPING TECHNOLOGY AND DISSEMINATION

6.1 Technical Adequacy of Existing Methods

The methods used to date for FIS mapping generally have been technically and scientifically acceptable and legally defensible because they have been intended for use by only one community and have employed standard procedures that have stood the test of time. Their ability to meet critical and minimum NFIP and community needs is more open to question because these needs extend beyond the immediate geographical area of a community covered by a particular FIS. The problem relates to floodplain management, disaster assistance and recovery, emergency planning, and other FEMA functions. Some of these functions are discussed elsewhere in this report in relation to problems that arise when one considers the entire region or watershed that might be affected by a major storm. Thus, it is appropriate that any modification of existing mapping methods also be based on the possibility of wider applicability to other FEMA functions.

The FIS guidelines (FIA 1979) specify that when adequate (5-foot contour interval) topographic maps do not exist, an equivalent accuracy normally should be obtained using aerial photogrammetric methods to delineate the elevation and boundary of the 100-year floodplain. Under these circumstances, elevations of valley and channel cross sections above water normally are determined to within ± 1 foot. The elevations of the boundary contours are therefore accurate to within 2 feet up to one-half a contour interval when a topographic map is used, and this has been adequate for FIS hydrology and hydraulics. Even though the third-order surveys needed for vertical photogrammetric control have an accuracy on the order of 0.3 foot, this does not mean that the resulting channel cross sections and boundaries have this accuracy.

When topographic maps are not available and photogrammetric means of determining cross sections are inappropriate, the FIS guidelines (FIA 1979) require trigonometric or differential leveling field surveys with vertical error tolerances of ± 0.5 foot across the 100-year floodplain. The basis of this requirement is vague but it appears to reflect what normally can be achieved if one is willing to pay for it. Further, it is not clear whether this 0.5-foot requirement is for accuracy, relative to some datum, or for the precision (repeatability) required for the instruments used. This requirement appears to be much

more restrictive, and more expensive, than that when photogrammetric methods are used. The committee believes that the actual interpretation of this FIS requirement leaves room for misunderstanding and results in unnecessary expense.

In addition, the committee does not believe that other FEMA functions have a requirement for 0.5-foot elevation accuracy for topography or that regional or river-basin studies will require such accuracy for flood prediction. The only reasonable requirement for 0.5-foot elevation accuracy or elevation differences would be associated with establishing insurance rates, particularly in developed areas. In this case, the requirement would seem to be for a determination of the relative height of the first floor of a structure with respect to the base flood elevation. Even though flood predictability involves an uncertainty of perhaps a few feet, this variation can be translated into risk and probability that the flood will exceed some given value. Insurance rates then can be assessed accordingly if the elevation of the property is well defined to an accuracy of 0.5 foot relative to the base flood elevation. Any grosser accuracy may be difficult to administer because the areal extent of flooding increases significantly. However, the committee notes that there is little or no quality control to assure that property elevations are determined with the accuracy needed to conform to the insurance premium charged. Normal homeowner property surveys do not involve elevation determination. Local determination of elevations may be from a map, comparison with similar structures, and other methods that may result in a premium too low to be sound financially. Thus, the committee believes that some relaxation of the 0.5-foot elevation accuracy for cross sections is in order but that a 0.5-foot elevation accuracy determination is needed for all property covered by the NFIP. This would suggest the use of rapid and efficient photogrammetric and inertial methods to achieve cost and time savings, particularly if the elevation accuracy required for cross sections is on the order of 1 or 2 feet. This also would facilitate the use of available USGS maps and other existing maps and would reduce the cost of new maps.

The committee also believes that an economical means of quality control is needed. Inertial positioning methods are suitable for the quality control component in the insurance program. A demonstration experiment may be necessary to establish costs and time, operational procedures, and other factors.

Identifying property elevations also will assist in resolving intercommunity problems and in establishing flood-insurance and floodplain-management programs for an entire region or watershed. The advantage of having all communities along the same river on the same topographic base has been recognized by both the committee and ANCo (1980).

The committee further believes that the requirements for additional surveys for photogrammetric mapping control should not increase and may decrease if modern methods are used. It believes that the overall costs for channel cross sections needed for regional hydrology and hydraulic analysis should decrease when photogrammetric methods are substituted for conventional field surveys. The previous discussion of hydrology and hydraulics suggests that the FIS guidelines (FIA 1979) should be revised to allow the use of significantly fewer channel cross

sections. This would result in a reduction in local accuracy requirements for elevations and would allow use of more economical surveying methods. Some of these are easily extended to entire regions and river basins. The inertial systems would be ideal for determining the slope of an entire river bed, thereby removing discontinuities that can occur between adjacent communities when the river-basin or regional approach to hydrology and hydraulics is not used. This should enhance the credibility of the FIS process and assist in the assignment of more equitable insurance premiums.

Finally, the committee believes that the FIS guidelines (FIA 1979) should be revised to provide for greater flexibility in the methods used to present results. Alternatives include the use of digital data bases or photographs. By reducing the number of map presentations, FEMA could reduce the number of surveys necessary for map control. In addition, the alternative methods of presentation would provide data useful throughout FEMA. Implementation could be at the federal or regional level or lower and could build on concepts developed at the prototype Map Information Facility (MIF), which now has been closed.

Communities in the emergency program are required to "obtain and reasonably utilize existing data" relative to floodprcofing and elevations of structures, but this requirement is not enforced consistently. It was noted earlier that Congress mandated floodplain management independently of the preparation of FISs; therefore, the lack of such studies should not be allowed to serve as an impediment to implementation of floodplain-management criteria when floodplain maps and data are available from sources other than FEMA.

Since 1960, the U.S. Army Corps of Engineers has prepared floodplain-information reports that include floodplain maps and elevation profiles for some 4,000 communities. The U.S. Geological Survey (USGS) has prepared maps of "approximate flood hazard areas" for 11,000 topographic quadrangles. Although less detailed than the Corps reports or NFIP FISs and lacking elevations, the USGS maps provide minimum data for many communities. In addition, other federal agencies including the Tennessee Valley Authority, the Soil Conservation Service, and the Bureau of Reclamation as well as state and local authorities have prepared floodplain maps of greater or lesser detail for many areas of the United States. Although these maps have been available, they have not been used to the extent possible and desirable in implementing the floodplain-management goals of the NFIP.

6.2 Technical Adequacy of Modified and New Methods

To properly assess modified and new methods for mapping that might reduce costs or save time, particularly for regional or river-basin studies, only those selected new methods deemed acceptable by professional land surveyors should be considered. Otherwise, the methods might not be legally defensible when tested in court. The types of surveying and mapping methods that would most likely be accepted are remote (satellite) sensing, photogrammetric data bases, and spinoffs from the nation's space program such as satellite doppler and inertial positioning systems. It also is expected that hybrid systems combining new and traditional methods will be developed. A representative system

in the latter category would be the airborne profiling of terrain system (APTS) now under development by the USGS.

The National Research Council's Committee on Geodesy (1980) has identified a national need for surveys that will better build a modern cadastre, a system for identifying the location of real property. Some of this property would be subject to the NFIP and floodplain management; therefore, any new mapping methods used for FISs should complement and supplement those for the cadastre.

Development of the elevation information needed to assess insurance premiums is an area that would benefit from interagency coordination since other FEMA functions need maps and current position information for use in planning and emergency operations. Digital data may be sufficient to meet all these needs, and new digitally oriented surveying and positioning methods (e.g., inertial and satellite Doppler positioning systems, analytic photogrammetry as embodied in the analytical photogrammetric positioning system, and, possibly, the APTS) have potential for use in disaster planning, assistance, and recovery. The committee believes that any new methods adopted for use in FISs, the NFIP, and floodplain management, in addition to being compatible with those used for building a modern cadastre and a digital cartographic data bank, should have FEMA-wide applicability so that the same equipment and methods can be used in other FEMA emergency functions.

The committee also believes that it would be beneficial for FEMA to establish external advisory groups of experts reflecting all of FEMA's interests to assist in the development of detailed plans for assessing new methods and taking advantage of new technology when it can save time and reduce costs in future FISs. It is especially important to determine expected costs, particularly since so little information has been released. All final decisions concerning adoption of any new method should be based on cost-effectiveness.

6.2.1 Remote (Satellite) Sensing

There has been intense research activity in the area of remote sensing since the first earth resources technology satellite was launched by NASA, and there are many published reports of the results of this research that suggest techniques for practical application of the technology. An extensive review of the literature and the references suggested by the American Society of Photogrammetry (which includes remote sensing) reveals little of value to the NFIP. Image resolution is so limited that only general flood boundaries can be determined with an accuracy of 0.1 to 0.5 km horizontally on the ground using LANDSAT imagery. This information may be useful in floodplain management, but it must be remembered that vertical elevation information is not available from the system. It is conceivable that during the next decade the Space Shuttle might make possible space photography offering coverage and resolution that will permit elevation determination, but this approach may be expensive compared to other methods available to FEMA. Overall, the committee believes that satellite remote sensing, although of some value for regional synoptic studies, holds little promise for the NFIP.

6.2.2 Photogrammetric Data Bases

For some time the Department of Defense has been using a photogrammetric technique, an analytical photogrammetric positioning system (APPS), for recovering position and elevation information on potential targets that can be identified and related to a photograph, and several APPS equipment models suitable for use by the public are commercially available. The U.S. Fish and Wildlife Service also has used an APPS to inventory wetlands (Brooks and Niedzwiadek 1980), and its experience would be valuable to FEMA because the same techniques could be used for documenting flood-prone areas and risk zones. This might help to combine floodplain-control procedures with wetland management.

A photogrammetric data base is a set of high-resolution stereo photographs covering an entire region, such as a river basin, at a scale that allows the user to obtain the accuracy required for position and elevation data. The photographs become human-readable, when viewed in stereo in an APPS instrument, and features of interest can be identified easily by an operator with only a few hours of training. The photographs also are machine-readable in that position coordinates of photographic images can be measured and transformed into digital ground coordinates by an associated computer and printed out within seconds. Copies of the same photographs can serve as a map for use in the field. Thus, an APPS provides a type of digital data bank with on-call "survey information" available at the desk top.

This type of photogrammetric data base would be of value in the NFIP and also would fill many other FEMA needs for planning, emergency operations, and other activities where reasonable accuracy and speed are important. To build a photogrammetric data base that might serve NFIP and floodplain-management needs, large-scale photographs will be needed together with surveys for ground control. Fortunately, economical methods are available that would make the system cost-effective. Satellite Doppler and inertial positioning systems could be used for the required first- and second-order control with the balance obtained by photogrammetric methods.

6.2.3 Modern Positioning Methods for Control Surveys

For economic reasons, the additional survey control needed for regional and watershed FISs probably should be accomplished using modern positioning methods. Those that are most likely to become acceptable to the surveying profession are satellite Doppler positioning for highest order control when it does not exist and inertial positioning to extend this control to the point at which photogrammetric methods suffice (Davis et al. 1981).

Several inertial positioning systems are commercially available (Schwarz 1979). Positioning accuracy can be less than 1 meter in three dimensions and careful operation of selected systems can provide accuracy down to 15 cm (Hadfield 1980). Inertial positioning systems (IPSs) can be used on the ground or in the air to determine profiles, stream slopes, and the position and elevation of any point of interest to the NFIP very quickly (within hours). Real-time position data of slightly less accuracy also are available and should be of considerable interest to FEMA for its emergency operations functions (Kurtz 1981).

An IPS is capable of determining the first-floor elevation and map position of every structure in a community rather rapidly and more accurately than if a map were used. An IPS combines gyroscopes, accelerometers, and computers to determine the distance traveled from some known starting point and relative location thereto. Thus, current position information is available and could be used to make a map while in transit or to guide the system to some coordinate of interest. The latter capability has value in search and rescue operations. An IPS also could be just what is needed to monitor quality control of insurance premiums set by local agents by determining what the actual difference is between random structures and the base flood elevation.

Even though maps will still be needed for planning and control, a combination of satellite Doppler, inertial, and photogrammetric methods is considered to be the best way to meet FEMA needs for position data over the next few years. The output is digital and can be entered into a digital cartographic data bank. Although an IPS can meet FEMA requirements for 15-cm elevations, relaxed FEMA requirements would make the use of an IPS even more attractive, particularly if it were used in conjunction with other modern systems. Significant cost and time savings are possible if projects are well planned. FEMA could use an external advisory group to prepare a demonstration, should it be timely.

6.2.4 Airborne Profiling of Terrain System (APTS)

The APTS, the ultimate hybrid system suitable for use in FISs and the NFIP, is in the process of development and is not expected to be available for several years should it prove to be technically adequate and cost-effective (Chapman and Starr 1979). The design requirement is for a 0.5-foot elevation accuracy in a profiling mode and it should operate more rapidly than an IPS. It may overcome some of the limitations of photogrammetric cross sections in selected areas because it uses a combination of inertial, laser ranging, photogrammetric, and other methods and determines positions from the air. The availability, while in flight, of elevation and position data would be of value throughout FEMA, but the APTS may not be able to accomplish this real-time function because of the computation required.

The APTS still will require the use of ground control surveys for which Doppler or inertial methods may be used. Thus, any FEMA initiative with respect to these systems would not be lost should the APTS be adopted later. Although the cost and time savings from use of the APTS remain to be determined, its possibilities are attractive, and the committee believes its development should be continued.

6.3 Relative Cost Considerations

The costs for photogrammetric surveys and control by satellite Doppler can be ascertained for a particular task by a variety of means because there is extensive experience in the surveying and mapping profession. The costs for the APTS cannot be estimated reliably at this time while the system is under development. The potential of IPSs is so great within FEMA that special effort should be made to establish

costs for their use in quality control as well as in regional or river-basin studies.

If it can be determined that higher premiums need to be charged in certain areas as the result of quality control surveys, FEMA might be able to justify the purchase of one or more IPSs for use in the NFIP and to support other FEMA functions. Cost could range from $500,000 to $1,000,000, but other agencies in the United States and Canada have found purchase attractive. An option would be to lease the equipment for use in the FIS and floodplain-management programs. The Corps of Engineers has done this and found it to be cost-effective (Campbell 1980, Davis et al. 1981).

The cost of a photogrammetric positioning system is an order of magnitude less if the photography is available. Such a system could be configured for a region for less than $100,000 and could be of great value to FEMA during emergencies. It is likely that FEMA could obtain the necessary photographs and control from another agency through a suitable interagency agreement. A suitable school for training operators already exists within the Defense Mapping Agency.

Both the photogrammetric and inertial positioning concepts were developed for use in large regions but can be adapted for use within cities where higher accuracy is needed. The specific cost for such an application would have to be determined by experiment and demonstration. The Defense Mapping Agency has experience with these systems and should be consulted.

With respect to the inertial positioning system, the Corps of Engineers has observed (U.S. Army Engineer Topographic Laboratories 1979) that "the system appears to have broad applications Corps-wide for conducting various civil works studies including flood insurance studies." Williams (1977) has stated the position of the Defense Mapping Agency as follows:

> Within my own Defense Mapping Agency (DMA), requirements for the installation of enormous amounts of high-quality mapping control over areas as large as Pennsylvania are being met with a two-man team operating an inertial navigation "black box" that we have installed in a Chevrolet Blazer and christened the IPS, for Inertial Positioning Systems.... It also can be operated in helicopters. Surveys at these speeds can bring huge savings in time and cost in control surveys for mapping areas where such systems can be applied...[and] may provide a powerful tool for surveyors in determining relatively precise terrain information needed for such applications as floodplain mapping and river valley development surveys....

The acceptability and usefulness of IPSs have been reported by several professional land surveyors (Cole 1980, Griffin 1977, Maddox 1980, Treftz 1981). Generally these surveyors have found IPSs to be technically and scientifically adequate and cost-effective for large, well-planned jobs. The legal defensibility of the IPS, were it to be tested in the courts, would appear to have support from respected members of the profession.

The question of costs is perhaps the only obstacle to wider adoption of IPSs. However, Table 4 shows that they have been especially

TABLE 4 Reported Costs of Inertial Surveying Systems

Location	Area	Elevation Accuracy	Cost	Cost by Conventional Surveys
Boone County, Missouri[a] (floodplain management)	300 km^2	30 cm	$69,000 2 men 1 vehicle 4 days	$107,000 6 men 4 vehicles 6 weeks
Prairie Mapping[b] Alberta, Canada	75,000 km^2 445 stations	15 cm ± 15 ppm	$877/station 7 weeks 2 men ?	$1700/station 18 weeks 12 men
Washington County, Oregon[c] (flood insurance study)	200 mi^2 555 stream crossings	± 8 cm	Less than ½ conventional	Conventional

[a]Based on data from U.S. Army Engineers Topographic Laboratories 1979.

[b]Based on data from Carriere et al. 1977 and Babbage 1977.

[c]Based on data from Campbell 1980.

cost-effective and have saved a significant amount of time when used in well-planned surveys over extensive areas.

In conclusion, costs, legal defensibility, and technical and scientific adequacy do not appear to inhibit the serious consideration of IPSs and other systems discussed in this section. The suggestions offered here should be implemented by FEMA, with guidance from an external group of experts, for the purpose of saving time and cost for future FISs and expanding their usefulness elsewhere within FEMA.

6.4 Role of Mapping in FEMA

The committee commends FEMA for its efforts to date in fostering the preparation and dissemination of flood insurance maps and studies. Since the advent of the NFIP in 1968, approximately 19,000 flood hazard boundary maps have been prepared and distributed indicating approximate flood-hazard areas within specific communities. Approximately 10,000 detailed FISs have been initiated and 7,100 completed. In the aggregate, this constitutes one of the greatest geographic information efforts in U.S. history.

In light of rising costs for each additional study, however, it is timely and appropriate for FEMA to review its floodplain-mapping program at this time. A substantial portion of population and investment at risk is covered by flood insurance studies and maps prepared to date. Communities remaining to be studied have lower flood-damage potential; therefore, the most expensive and detailed flood studies may not be justified. Furthermore, the legal analysis of the ANCo report (1980) indicates that the most sophisticated form of FIS may not be legally required as a prerequisite to minimum floodplain-management regulations (see chapter 7). Nonetheless, the demand for maps will not abate. One of the advantages of maps is that planners can work on them. If floodplain-management efforts are to be strengthened, maps will be needed, and the committee believes that the actual demand for maps will increase manyfold.

The committee also believes there is need for auxiliary data on property elevation in order to improve the risk determinations used in setting insurance premiums. At present, flood insurance maps do not provide three-dimensional coordinates of a property, but such information likely would be widely used if it were available. For example, the relative height of a property above the base flood elevation is what determines the premium rate, but this information presently is not included on flood insurance maps and a local determination of first-floor elevations is required. For new property, this information can be obtained easily when the property survey usually required by lenders is performed. For older properties, however, a resurvey is required and likely would cost a property owner at least $50 and in many situations considerably more. Thus, for older property it is easier for an agent and an owner to "agree" on what the elevation should be for entry into the rate tables. It is unlikely that such agreements result in higher premiums and there is a high probability that an inadequate premium will be determined, to the detriment of the NFIP for years afterward.

One option would be to establish quantitative elevations on a one-time basis using existing equipment, large-scale photographs of recent

vintage, and well-established methods of analytical photogrammetry. From the photographs the photo interpreter can identify what appears to be the first floor of the structure, as might be indicated by a stair landing or stoop. The photogrammetrist can measure the coordinates of this point on a stereo pair of photographs and can calculate the elevation of the first floor. Much of this work can be semi-automated. For example, the APPS IV system already is in extensive use for similar purposes by the Department of Defense and for wetland mapping by the Fish and Wildlife Service. Elevations for a residence could be determined in about 30 seconds using this system were photographs available and the concept implemented.

Another option would be to rent inertial surveying systems for a one-time determination of first-floor elevations for an entire community. Such equipment has been available and in use for some time by the Department of Defense, the Bureau of Land Management, the USGS, and others. For FEMA use, it is visualized that one would drive through the community with the system and visit each house in the manner of the mailman. Both horizontal and position information to an accuracy of 0.5 foot can be obtained as rapidly as a person can move from one house to the next. Coordinate information so obtained could be transformed and integrated into a data base to supplement and check the information obtained from Census maps and other sources (e.g., the photogrammetric alternative in cases where the first-floor elevation could not be determined from the imagery).

With either option FEMA still will need to require three-dimensional survey information for new property in order to maintain the expanded data base, and this information would be of immense value in floodplain-management efforts and, to some extent, in emergency planning efforts. Thus, serious consideration should be given to establishing a reporting requirement for such information for all new property development in risk areas. Again, this would increase the cost-effectiveness of the expanded operation and increase the usefulness of the digital storage concept.

The two options suggested would be easy to test on an experimental basis. It could be that the costs would be offset by gains to the other FEMA functions (e.g., emergency planning and preparedness and disaster assistance and recovery). If results prove both promising and financially feasible, the proven alternative then might be used for a one-time update of any other currently existing data base. Later such a system could be replicated, decentralized, and implemented in each FEMA region to better support emergency operations and to indirectly increase the cost-effectiveness of the effort.

Such an approach raises several related issues that FEMA management may wish to explore. The primary issue relates to the overall mapping needs of FEMA. The above comments have indicated that there is no reason to consider NFIP mapping needs in isolation of other FEMA needs.

A related issue concerns the coordination of FEMA mapping activities with other federal mapping functions. The National Research Council's Committee on Geodesy (1981) has recently addressed issues of governmental organization in the mapping area. It is expected that the USGS will receive lead agency responsibility as a result of this report. FEMA (FIA) does not appear to have utilized USGS mapping services in any extensive way. The committee believes such cooperation

is vital and may lead to reduced costs; it at least will simplify some aspects of the distribution and maintenance problem.

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Chapter 7
JUDICIAL REVIEW OF FIS PRODUCTS

Management of coastal and riverine flood-prone areas through state and local regulation is a comparatively recent phenomenon in the United States. The widespread adoption of comprehensive land-use zoning following the 1926 U.S. Supreme Court decision of Ambler Realty Company v. Village of Euclid (272 U.S. 365, 1926, U.S. Supreme Court) did not involve restraints on the private development of floodplains. As recently as 1955, an authoritative study (Hoyt and Langbein) of flood problems stated:

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

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

The long delay in the emergence of floodplain regulation may be explained by three factors. First, Congress in the Flood Control Act of 1936 and its successors declared that the federal government would be a party to the construction of flood-control works. To date, more than $10 billion has been spent in the task of taming the rivers through flood-control reservoirs, levees and dikes, channelization, and other structural means. Most of this work was performed at federal expense with involvement by states and local governments confined to the provision of easements and rights-of-way on locally oriented projects. The impression became widespread that flood problems were being solved and that no further action of a regulatory nature was required. Even where the U.S. Army Corps of Engineers required state or local "assurances" that downstream floodplains would be regulated to prevent encroachment, such assurances have not been widely enforced.

A second factor in the slow acceptance of floodplain regulation was uncertainty concerning the constitutionality of such measures. It was widely believed that courts would uphold only restrictions based on precise and unassailable engineering studies. For example, two leading hydrologists (Leopold and Maddock 1954) wrote:

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

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

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

The inevitable price of this widespread encroachment on floodplains has been ever-increasing flood losses. Despite the expenditure of more than $10 billion on federal flood-control works, average annual flood damages have been rising consistently since 1936 to a currently estimated total of $3.8 billion per year. The loss of lives has decreased in major river valleys due to the combined effect of improved flood-warning systems and structural systems but is considered to be a major concern in areas subject to flash flood or coastal hurricane (White and Haas 1975).

Following a series of devastating floods in the 1950s and early 1960s, the nation began to re-examine the flood-damage issue. The influential report of the Task Force on Federal Flood Control Policy (U.S. House of Representatives 1966) recommended numerous changes in the national approach to floods. Although admitting that structural measures still were needed in certain areas, the report stressed the need for improved use of nonstructural measures including floodplain regulations, flood insurance, and relocation of occupants from flood-hazard areas. This report was forwarded to Congress by President Lyndon Johnson concurrently with the issuance of Executive Order 11296, which ordered all federal agencies to consider the flood impacts of their actions. In 1968 Congress established the NFIP, which made floodplain regulation an integral component of federal policy for the first time.

Fortunately, by this time a firm legal basis for the regulation of floodplains was finally in the process of development. No decision by the U.S. Supreme Court has directly addressed the question of floodplain zoning. However, in the 1962 decision of Hempstead v. Goldblatt (369 U.S. 590) involving the regulation of gravel quarries within a residential area, the Court enunciated a general test for the imposition of public authority to abate hazardous situations:

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

The Court went on to re-affirm its traditional view that the legislative determination will be upheld unless clearly arbitrary and capricious.

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

7.1 Judicial Recognition of Flood Hazards

In the surprisingly few cases that directly raise the issue, courts have been almost unanimously willing to give explicit recognition to the threat of flood hazards as a proper object of public regulation. In a 1930 New Hampshire case, American Land Co. v. City of Keene (41 Fed. 2d 484), a federal Court of Appeals stated the issue in terms of consumer protection. Where the purchaser of a flood-prone site from the City of Keene objected to the subsequent imposition of floodplain restrictions on his use of the land, the court upheld the restraints as a "proper exercise of the city's policy power in order to protect possible purchasers [from] being victimized, as the plaintiff was victimized by the city itself." Protection of the unwary buyer or tenant was cited by Dunham (1959) as a proper ground for public intervention along with the avoidance of public rescue costs and protection of downstream interests from the risk of greater flooding due to individual encroachments.

Restrictions imposed following a flood disaster to mitigate future losses were viewed favorably by the Connecticut Supreme Court in 1958, Vartelas v. Water Resources Commission (153 A. 2d 822). The case involved an "encroachment line" established by the state that prohibited all reconstruction within a specified distance of the Naugatuck River. Upon challenge by a property owner who retained only 60 square feet outside of the encroachment line, the court declared:

> Reasonable regulation of the size and area of buildings and of the type of material used in them and the method of construction has long been recognized as legally proper....The loss of human life and the destruction of property wrought by the floods in August 1955 justified the legislature in conferring upon the commission broad powers to adopt preventive measures against their repetition. The trial court

> found that the encroachment lines as established by the commission extend for several miles along the Naugatuck River, accord with sound engineering principles and statutory requirements, and were designed to reduce hazard to life and property in the event of recurring floods.

The problem of structures erected in violation of applicable encroachment line restrictions was confronted by the Iowa Supreme Court in 1968, Iowa Natural Resources Council v. Van Zee (158 N.W. 2d 111). The court strongly endorsed the constitutionality per se of such restrictions declaring:

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

But the court refused to order the removal of certain levees constructed by the defendant subsequent to the enactment of state floodplain restrictions. Instead it merely required the filing of an application for a permit. A strong dissent argued that a mandatory injunction for removal should be issued on the ground that such unauthorized encroachment amounts to "public nuisance." (A contrasting view was expressed in a 1971 Florida coastal wetlands case, U.S. v. Joseph G. Moretti, Inc. [331 F. Supp. 151, (S. D. Fla.)], in which a U.S. District Court ordered immediate removal of fill illegally placed in a Florida bay.)

Regulation of flood-prone areas at the local level appeared with increasing frequency after 1960. Perhaps the strongest judicial decision upholding such municipal restrictions was the 1972 Massachusetts opinion in Turnpike Realty Co. v. Town of Dedham (284 N.E. 2d 891). Dedham in 1963 had amended its zoning by-laws and zoning map to establish a "floodplain district" that included most of the plaintiff's land in a "low swampy area" bordering the Charles River. Within the floodplain, the use of land was limited to "woodland, grassland, wetland, agricultural, horticultural, or recreational" purposes. Citing the 1959 Dunham law review article and other authorities, the court stated:

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

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

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

At the municipal level, conflicting motives and objectives may confuse the floodplain-management situation. In Turnpike Realty, the ordinance listed among its purposes, in addition to the protection of

public health and safety from floods, the conservation of "natural conditions, wildlife, and open spaces for the education, recreation, and general welfare of the public." The court admitted that such objectives would not support the ordinance in their own right but that they are merely incidental to the ordinance which is "fully supported by other valid considerations of public welfare." The court distinguished a 1963 New Jersey case, Morris County Land Co. v. Parsippany-Troy Hills Twp. (193 A.2d 232), in which a municipal wetlands restriction was invalidated on the grounds that it served merely environmental or conservation goals, not the alleviation of flood hazards.

7.2 Evidence of Flooding

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

> Petitioner's land "will have water on it ranging anywhere from practically nothing up to...3 feet of water annually." He further testified that once the flow in the Charles River exceeds 1280 cubic feet a second [the corresponding stage of] which is equivalent to the approximate elevation of the petitioner's land...[the] latter will be flooded. The flow of the Charles River...exceeded that level in 1936, 1938, 1955, and 1968. Barrows stated that he personally went to the petitioner's land in March 1968 and observed that it was covered with "approximately 4 to 5 feet of water."

When flooding is recent and notorious, courts may take judicial notice as in the Vartelas case. But when the hazard is less obvious, expert testimony of the kind used in Turnpike Realty normally is involved. Given such assistance, courts are willing to sustain measures of unusual kind or severity. The California Supreme Court in 1953, McCarthy v. City of Manhatten Beach (264 P.2d 932), upheld a municipal ordinance creating a "beach recreation district" with the benefit of testimony that the plaintiff's land on the Pacific shoreline was subject to inundation during heavy storms. A California Appellate Court in 1972, Turner v. County of Del Norte (App., 101 Cal. Rptr. 93), upheld an absolute prohibition of residential or commercial structures in a floodplain upon proof that the site had been flooded four times since 1927. (The zoning in question was adopted in 1965 as a prerequisite to the approval of a flood-control project to be constructed by the U.S. Army Corps of Engineers.) The New Jersey Supreme Court in a 1966 decision, Spiegle v. Borough of Beach Haven (218 A.2d 129), sustained a total ban on construction of homes seaward of a municipally established "building line." The court rested its judgment on:

> Unrebutted proof that it would be unsafe to construct houses oceanward of the building line...because of the possibility that they would be destroyed during a severe storm--the result which occurred during the storm of March 1962. Additionally, defendants admitted proof that there was great

> peril to life and health arising through the likely destruction of streets, sewer, water and gas mains, and electric power lines in the proscribed area in an ordinary storm.

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

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

When proof to the contrary is offered, namely that no flooding has been known to occur on the site in question, judicial tolerance of floodplain regulations is more problematic. A Michigan Court of Appeals in 1971, Sturdy Homes, Inc. v. Township of Redford (186 N. W. 2d 43), invalidated the application of an ordinance to property where:

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

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

7.3 FISs as Basis for Regulation

The obvious question arises as to how courts will deal with floodplain zoning when it applies to land that has not been flooded within record but that lies within the reach of a flood of estimated probability (e.g., the 100-year flood). This forcefully poses the issue as to the weight to be given to FISs as evidence of the potential for flooding. Unlike the situation involving recent and notorious flooding or risk of flooding easily verified by an expert witness, extreme weight is given to FISs if used as a basis for regulation and other hazard-mitigation measures. What level of reliability is required for a FIS if it is to be legally defensible when it identifies as flood-prone, areas that have not recently, or ever, been flooded?

Technical uncertainty is an obstacle to any program of public regulation but not necessarily an insurmountable obstacle. As early as 1926, the U.S. Supreme Court in the Ambler Realty decision concluded:

> The inclusion of a reasonable margin, to insure effective enforcement, will not put upon a law, otherwise valid, the stamp of invalidity. Such laws may also find their justification in the fact that, in some fields, the bad fades into the good by such insensible degrees that the two are not capable of being readily distinguished and separated in terms of legislation.

Regulation of land, air, and water necessarily involve "inclusion of a reasonable margin" to overcome inadequate data and imperfect criteria for establishing boundaries between the permissible and the forbidden.

FISs involve technical uncertainty at many levels: hydrologic, hydraulic, survey, and mapping. Errors inherent in earlier stages of analysis are compounded by subsequent levels of computation. Mapping alone involves the representation of data, no matter how reliable, on base maps of usually inadequate scale. Uncertainty thus abounds in the FIS process (Dingman and Platt 1977).

One response to this problem is to place greater legal weight on the hydrologic and hydraulic data independently of their representation on maps. Thus, flood elevations and profiles often are regarded as more legally defensible than maps by which these vertical elements are converted into horizontal surrogates.

Another approach is to recognize the inevitability of technical uncertainty and to extend a strong presumption of validity to regulatory measures based on conscientious, if not the most sophisticated, methods and procedures. Bracken and Baram studied this issue in detail for FEMA (under subcontract to ANCo) and its findings (unpublished report to FEMA, July 31, 1980) are quoted at some length below:

> A number of regulatory and benefits programs other than the NFIP are similarly based on the gathering of data. In such cases, the courts have not hesitated to approve findings made in such programs that fail to take into account every detail of each individual's particular circumstances. Indeed, one can hardly imagine a FIS that "cannot be criticized as omitting some item of information." Typically, in evaluating such a criticism, a court will rely heavily on the burden on the agency and its limited resources and will refuse to conclude that Congress intended the agency to shoulder impossible burdens. Further, if satisfied that the agency complied fully with required procedures and exercised its discretion as to accuracy/cost issues reasonably, the court is more likely to affirm the agency decision. Thus, it can be concluded, with respect to the NFIP, that it was not the intention of Congress to force FEMA to gather such precise and detailed data in the pursuit of correctness in each FIS that administrative practicality and overall program accomplishment are sacrificed. [Emphasis added.]

> Trade-offs between cost and accuracy in data collection are made in many other agencies as well. The courts have frequently used a "rule of reason" to determine whether the trade-off is one which is (1) sanctioned by the enabling statute, and (2) a reasonable action towards the achievement of the relevant statutory objective. For example, in Environmental Defense Fund v. Costle, the federal district court found that the Environmental Protection Agency's decision to base its findings on river-basin salinity (for the Colorado river basin) and its subsequent regulatory determinations on readings taken at but three locations in a vast, interstate river basin met standards of rationality

and was not arbitrary or capricious. The court refused to rule that a more expensive and accurate measurement system was legally-required.

The issue of tempering statutory mandates with considerations of administrative necessity was recently considered by the D.C. Circuit Court of Appeals in Alabama Power Co. v. Costle, a case involving challenges to the Environmental Protection Agency's regulations on the prevention of significant deterioration of air quality. The court conceded that administratively created exemptions to statutory commands are not to be favored and cannot be approved if they are inconsistent with the clear intent of the relevant statute. Nevertheless, the court stated: "Considerations of administrative necessity may be a basis for finding implied authority for an administrative approach not explicitly provided in the statute. The relevance of such considerations to the regulatory process has long been recognized. Courts frequently uphold streamlined agency approaches or procedures where the conventional course, typically case-by-case determinations, would, as a practical matter, prevent the agency from carrying out the mission assigned to it by Congress."

The court thus acknowledged the principle that an agency official should not be required "to do an impossibility." A federal district court has elaborated on this point somewhat: "So long as a good faith effort appears to have been made to supply available information, and no information material to the choices of management options...has been withheld, the...finding should be upheld." Nevertheless, the Alabama Lower Court refused to accept blindly agency claims of impossibility, concluding that it must scrutinize such claims carefully to assure that more than mere administrative inconvenience is being asserted.

As long as perfect accuracy and certainty are not economically feasible and indeed impossible to achieve in a FIS, it is permissible for FEMA to base its program implementation on a "rule of reason" as to its resource commitments for the conduct of studies and to focus on providing data for an entire community simultaneously at reasonable cost. Therefore, the decision to undertake restudies or to adopt new methods should continue to be based on FEMA concern over its ability to maintain the total cost of data collection at a reasonable level and its need to furnish data sufficient to lead to legally defensible approximations.

Another source of uncertainty in flood insurance studies is analytical uncertainty and limitations. Given a high variability in the adequacy of available data from stream to stream, various analytic techniques are often required and this necessarily introduces differential costs and

> accuracies. Thus, the agency should adopt a trade-off process that ends at the point at which the base flood estimates and elevations fall within an acceptable engineering level of tolerance.
>
> The question of whether a single number (or elevation) can be the basis of regulation when, because of unavoidable technical uncertainty only a range of numbers can be supported by the studies underlying the regulation, has been considered a number of times by courts in other contexts. In E. I. DuPont de Nemours & Co. v. Train, for example, the U.S. Surpreme Court answered this question in the affirmative when it was posed in the context of EPA's industrial effluent limitation regulations. Thereafter, in Weyerhauser Co. v. Costle, the D.C. Circuit Court undertook to set a standard for reviewing a regulatory limitation. The court noted the problem of "technological and scientific uncertainty" that must be overcome as well as possible in conducting such an analysis. The Court then quoted its own earlier statement: "Where existing methodology or research in a new area of regulation is deficient, the agency necessarily enjoys [a] broad discretion to attempt to formulate a solution to the best of its ability on the basis of available information." [Citations omitted.]

7.4 Revision in Light of New Data

No matter what level of technical detail was involved in the initial preparation of a FIS, basic concepts of fairness and equity suggest that maps and regulations should be revised and updated as new data become available. The leading flood-related case on this point was a 1974 Maryland decision, A. H. Smith Sand and Gravel Co. v. Department of Water Resources (313 A. 2d 820), which held that when a public authority bases its floodplain regulations on computer simulation, such estimates must be updated in light of actual subsequent flood experience. The case involved water-pollution regulations adopted by the State of Maryland in 1970 that restricted the operation of gravel quarries within a designed 50-year floodplain. After Hurricane Agnes in 1972, the operator of a gravel quarry brought suit to challenge the constitutionality of the restriction per se and its application to his property. The court sustained the overall validity of the measure but agreed that the department's estimate of the 50-year floodplain should be revised in light of recent experience:

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

The plaintiff introduced testimony that Agnes was 1.4 times greater than a 50-year flood at his property. This would indicate a reduction

in the size of the 50-year floodplain even though plaintiff's land apparently was inundated by Agnes. The court rejected an argument by the state that a broader area should be regulated in the expectation of future development in the watershed upstream from the plaintiff's land.

In a 1979 case, Roberts v. HUD (473 F. Supp. 52, N. D. Miss.), directly involving NFIP flood elevations it was held that FISs must be based on past or historic flood data. However, projected elevations must be revised if and when subsequently completed flood-control works influence potential flood levels:

> The crux of the case is whether the floodplain designation was rendered inaccurate by the failure of the federal officials to take into account potential changes in the Tombigbee River in connection with the construction of the lock and dam...the channelling, widening and dredging...and the construction of a new four-lane bridge.
>
> The record shows that these points were considered by the... officials...but absent any historical data... they were not taken into account.... [These plans] do not constitute past knowledge or information that the flood elevations proposed ...are scientifically or technically incorrect.... [T]his historical information...is required...in order to make a necessary showing that the...officials have acted in an arbitrary and capricious manner....
>
> Upon the completion of [these proposed projects]...it may well be that certain areas presently included in the floodway should be removed therefrom because of altered conditions. The City of Aberdeen has the word of [FEMA] that if such changes justify alterations to the pertinent floodplain, necessary action will be taken...indeed, the...regulations...require that where...base flood elevations...increase or decrease...from physical changes...the Administrator is directed to accumulate additional technical data... 24 C.F.R. 1915...so that flood conditions, risks, permanent rates and floodplain management requirements will be based on current data.... [The] regulations provide a remedy, should historical data prove to be inaccurate or otherwise misleading, to correct whatever injury may have resulted from the original determination.

7.5 Moratoria on Pending Flood Studies or Projects

Some municipalities that experience frequent flooding impose a temporary moratorium on the issuance of building permits pending completion of flood studies or structural flood-control projects. As in cases involving overloaded sewer systems, courts are inclined to be tolerant of moratoria that are reasonable in purpose and duration. For example, in a 1973 case, Cappture Realty Corp. v. Board of Adjustment of the Borough of Elmwood Park (313 A. 2d 624), the New Jersey Superior Court sustained a moratorium on development in the floodplain of the

Passaic River that had been in effect for two years pending completion of flood-control plans and adoption of permanent floodplain zoning. Although the ban in question was imposed pending completion of a flood-control engineering project (channel straightening), the court cited with favor decisions where moratoria were upheld to allow time to complete flood studies and zoning:

> The enactment of interim ordinances has been upheld as a recognized and logical addition to comprehensive municipal planning during periods required to create or revise comprehensive zoning plans. [Citations omitted.]

In 1975, a New Jersey Appeals Court, in Cappture Realty Corp. v. Board of Adjustment of the Borough of Elmwood Park (336 A. 2d 30) (see also New Jersey Builders Association v. Town of Ocean [319 A. 2d 255, 1974]), upheld continuation of the same ban but cautioned that its patience was not limitless:

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

7.6 Appeals Concerning FIS Determinations

The National Flood Insurance Act provides a detailed appeal process to protect the rights of property owners and communities against inaccuracy in flood insurance studies. This protection addresses flood elevations in particular. Following mandatory publication of proposed flood elevation determinations, a period of 90 days is allowed for appeals by the community property owners or lessees. However, the scope of appeals is limited:

> The sole basis for such appeals shall be the possession of knowledge or information indicating that the elevations being proposed...are scientifically or technically incorrect, and the sole relief which shall be granted... is a modification of the...proposed determination accordingly.

(According to Bracken and Baram, the strict provisions of the Act are augmented by the Administrative Procedure Act that applies to all federal agency determinations of this kind.)

The question naturally follows as to whether it is sufficient to show that the proposed elevations are likely to be "scientifically or technically incorrect" and therefore unreliable or whether "better" data must be provided by the appellant as a substitute for FEMA's proposed elevations. In other words, can the community or property owner simply call attention to flaws in FEMA's data and procedures or must they go to the expense of providing more reliable data? Who bears the burden of proof? Earlier discussion of technical uncertainty, however,

strongly suggests that agency findings are to prevail unless proven inaccurate by other more detailed studies. The mere challenge of "technical uncertainty" would not in itself be grounds for recision.

The committee is aware that FEMA resolves most appeals of FIS determinations through consultations with the appellant communities. Although it favors the prompt and inexpensive disposition of disputes through such expedients, it observes that when appeals are prolific, there may be need for restudy of the community, reach, or watershed in question.

7.7 References

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Chapter 8
RESEARCH NEEDS

8.1 Technical Issues

The committee believes that the nature of the NFIP with its flood-insurance and floodplain-management goals is such that specific technical issues exist and will continue to arise. Thus, it recommends that FEMA establish a problem-oriented research program that will provide for a continuing working group of experts reflecting all FEMA interests to assist in identifying specific problems as they arise, developing a scope for required research, and monitoring the research. Several examples are presented below to illustrate the types of problems that will benefit from such treatment. What they have in common is that they are narrow in scope, require specific answers, and are directly and immediately applicable to the FEMA program. To achieve results, however, the research efforts must be closely monitored.

Several engineering aspects of the FIS process require attention:

1. The impact of the Water Resources Council decision to adopt and recommend the log-Pearson Type III (LP-III) distribution for uniform flood frequency analysis for streamflow records requires assessment. This will involve determining: the theoretical and historical bases for the use of the LP-III distribution in flood frequency analysis; the statistical characteristics of the LP-III; the impact of the concept of separation on use of the LP-III and, in turn, on FIA policy, particularly in terms of the financial integrity of the NFIP; whether LP-III estimates are biased when flood peaks are from a single underlying distribution, when flood peaks result from a mixture of distributions, or when used in subsequent regional analyses; whether there is a sound basis for FEMA to accept or to reject the LP-III as a standard distribution; and what FEMA should recommend to the Council concerning use of flood frequency distributions.

2. An assessment of how the results of the Water Resources Council comparative study of rainfall-runoff models can be applied to FEMA programs is needed. This will involve summarizing the results of the model comparison; analyzing the study, its aims, its achievements, and its shortcomings; ranking model performance by accuracy, consistency, and reproducibility; and determining whether any models are clearly

dominant over any others (i.e., whether any one model definitely can be considered inferior or superior).

3. A method for better allocating effort in the performance of FISs is needed. This will involve critical review of the literature on the relation of accuracy of FIS results (flood stages, flood boundaries, flood insurance zones, and flood insurance rates) to accuracy of inputs; critical review of the literature on the relation of cost to accuracy for input data for FISs; development of a model for the study of FIS cost-effectiveness; and conduct of sensitivity analyses on the model developed that stress the model over the range of variables developed.

8.2 Intergovernmental Issues

Similar examples can be presented for the nonengineering aspects of the FIS process:

1. With respect to floodplain management, for example, cost-sharing must be addressed. There is need to explore how cost-sharing can be used to further the objectives of NFIP-related activities; which NFIP activities directly or indirectly benefit nonfederal entities (e.g., the use by community emergency planners of information collected as part of or supplemental to FISs); how benefits derived by various parties can be quantified; what impact would result from the use of federal funds as incentives (e.g., Section 1362 acquisition funding could be used to reward communities aggressively enforcing floodplain-zoning regulations) or as subsidies (e.g., in the actuarial as opposed to the subsidized insurance rates); and what administrative or legislative actions related to cost-sharing are needed to improve the cost-effectiveness of the NFIP.

In the longterm, the relative significance of the impact this program will have on flood-damage mitigation will be directly related to the effectiveness of the local floodplain-management efforts. Local units are required presently to enact certain floodplain-management ordinances in order to qualify for participation in the program. However, there is no real reward system which encourages continuing local diligence for this task. Procedures employed by insurers in the prevention of loss by fire seem particularly pertinent to possible underwriting and rating concepts for flood insurance. For example, fire insurance rates in an individual city are a function of the adequacy of the community's water supply and firefighting systems. Conceivably flood insurance rates, subsidized or actuarial, should be made a function of the adequacy of a community's floodplain-management program. The issue deserves research attention.

8.3 Financial Issues

The overall financial health of the NFIP is of major concern to FEMA and leads to consideration of questions concerning the adequacy of the rate structure, the areal diversification of risk. These subjects are closely related to the floodplain-management and cost-sharing issues raised above and appear to offer some opportunity for effective research as follows:

1. The FIA recently announced an increase in insurance rates. Agency action on this matter appears to have been influenced by a review it conducted of the 28-month period between January 1978 and April 1980. The indicated average annual oparating deficit based on the review period statistics, assuming they apply to the number of policies now in effect, would exceed $312 million. Indeed, for all of FY 1979 earned premiums are reported to be $117 million with incurred losses of $482 million, a 412 percent loss ratio. For FY 1981, $575 million of FEMA's budget has been allocated to the National Flood Insurance Fund. This appears to anticipate a 350 to 400 percent loss ratio. Research effort directed toward this issue should provide for sufficient examination of the general damage-probability relationships and present policy distribution to permit a reasonable appraisal of the average annual damage to be sustained by insurance zone. This appraisal should be carried far enough and be based on sufficient sample size to assure that whatever rate structure is proposed adequately meets the requirements of the National Flood Insurance Act.

2. Figure 1 indicates that a very high percentage of the dollars at risk in this program are concentrated in four major metropolitan areas. This necessarily leads to questions concerning potential problems which could arise from the indicated lack of a real diversification of the risk. Specifically, the impact of this issue on the possible probability distribution of the annual claims to be incurred by the NFIP needs to be explored. This question is worthy of research and should be a logical next step upon completion of the prior item.

3. There appears to be ample reason to examine the long-range financial consequences associated with continued subsidization of flood-prone properties. The NFIP obviously incurs a high degree of subsidization. Subsidy maintained in perpetuity would appear to discriminate unduly against those who do not own flood-prone property. This would appear to be ample reason to research alternative policies for the eventual phasing out of the subsidized portion of the program.

Appendix A
RIVERINE FLOOD INFORMATION NEEDS

(from Anderson-Nichols and Company, Inc., Promising Methods and Procedures for Performing Riverine Flood Insurance Restudies, 1980)

User Group	Uses	Type of Data	Data Needed	Delivery Medium
FEMA	Meet agency objectives of flood hazard mitigation, planning, response, and recovery; implement E.O. 11988 and 11990; provide technical assistance to communities.	Identification of hazard area	Flood boundaries[a]	Maps
			Insurance rate zones[a]	Maps
			Flood elevations[a]	Maps or profiles
			Elevation reference marks	Maps or tables
		Critical subareas	Floodways[a]	Maps
			Flood velocities	Maps or tables
			Warning and evacuation time and routes	Maps and tables
			Dam and levee failure zones	Maps
			Erosion areas	Maps
		Land-use	Insurable structures	Maps
			Critical facilities	Maps
		Flood timing	Rate of rise and duration	Technical report or hydrographs
		Socio-economic	Stage and damage data	Technical reports
			Extreme hardship areas	Reports
		Special conditions	Subsidence areas	Technical reports
			Sink holes	Technical reports
			Ice jams	Technical reports
			Debris load	Technical reports
			Pollutants	Technical reports
	Review appeals	Supporting documentation	Cross sections	Originals or microcopies
			Work maps, hydrologic and hydraulic calculations	
			Correspondence[a]	
Other federal agencies--COE, SCS, TVA, USR, USGS	Technical assistance; Permit processing[a]; flood and erosion control	Hydrologic and hydraulic input and output	Cross sections	Digitized data on magnetized tape or punch card
			Discharges, hydraulic characteristics	
	Implement E.O. 11988 and 11990; disaster relief; and compliance with NEPA	Hazard area identification	Flood boundaries[a]	Maps
			Flood elevations[a]	Maps or profiles
		Critical subareas	Floodways[a]	Maps
			Flood velocities	Maps or tables
		Flood timing	Rate of rise and duration	Technical reports or hydrographs

User Group	Uses	Type of Data	Data Needed	Delivery Medium
National Weather Service	Real time flood prediction	Hydrologic and hydraulic input and output	Cross sections Discharges Hydraulic characteristics Flood boundaries Flash flood areas	Digitized data on magnetic tape or punch card Maps
SBA, Agr. Stabil. and Conserv. Serv. SCS, U.S. Forestry Serv.	Disaster relief; implement E.O. 11988 and 11990	Identification of hazard area	Flood boundaries[a] Flood elevations[a] Floodways[a] Flood velocities Erosion areas	Maps Maps or profiles Maps Maps Maps
EPA, HUD, DOI, DOC, DOA, DOE	Construction grants; implement E.O. 11988 and 11990	Identification of hazard area	Flood boundaries[a] Flood elevations[a] Floodways[a] Flood velocities Erosion areas	Maps Maps or profiles Maps Maps Maps
Department of Transportation	Design of stream crossings	Identification of hazard area	Flood boundaries[a] Flood elevations[a] Floodways[a]	Maps Maps Maps
FHL Bank Board, VA, FHA	Home mortgage insurance	Identification of hazard area and degree of risk	Flood boundaries[a] Flood elevations[a] Floodways[a] Insurance rate zones First floor elevations	Maps of HIF[b] Maps or profiles or HIF[b] Maps or HIF[b] Maps or HIF[b] Tables or maps
All federal agencies	Implement E.O. 11988 and 11990; compliance with NEPA	Identification of hazard area Critical subareas	Flood boundaries[a] Flood elevations[a] Floodways[a] Critical environmental areas	Maps or HIF[b] Maps or HIF[b] Maps or HIF[b] Maps
State agencies	Technical assistance; permit processing; A-95 project review; stream crossing design; disaster preparedness warning, evacuation, response, and recovery; land-use planning	Identification of hazard area	Flood boundaries[a] Flood elevations[a] Future development hazard areas Elevation reference marks	Maps Maps or profiles Maps Maps

User Groups	Uses	Type of Data	Data Needed	Delivery Medium
State agencies (cont'd)		Critical subareas	Floodways[a]	Maps
			Flood depths[a]	Topographic maps
			Flood velocities	Maps or tables
			Erosion zones	Maps
			Dam and levee failure zones	Maps
			Critical environmental areas[c]	Maps and inventory statistics
			Soil classifications	Maps
		Land use	Existing land use	Maps
			Critical facilities[d]	Maps
		Socio-economic	Flood damage estimates	Technical reports
			Extreme hardship areas	Reports
		Flood timing	Rate of rise and duration	Technical reports
			Flood seasons	Reports
			Flash flood areas	Maps
Communities and Private interests	Comprehensive floodplain management: hazard identification, mitigation, preparedness, warning evacuation, response and recovery; land-use control	Identification of hazard area	Flood boundaries[a]	Maps
			Flood elevations[a]	Maps or profiles
			Flood depths	Topographic maps
			Future development hazard areas	Maps
			Elevation reference marks	Maps
		Critical subareas	Floodways[a]	Maps
			Flood depths[a]	Maps
			Flood velocities	Maps
			Erosion zones	Maps
			Dam and levee failure zones	Maps
			Critical environmental areas[c]	Maps
			Soil classifications	Maps
		Insurance risk	Insurance rate zones[a]	Maps or HIF[b]
			First floor elevations	Tables or maps
		Land use	Existing land use[a]	Maps or HIF[b]
			Critical facilities[d]	
		Socio economic	Flood damage estimates	Technical reports
			Extreme hardship areas	Reports

User Group	Uses	Type of Data	Data Needed	Delivery Medium
Communities and Private Interests (cont'd)		Flood timing	Rate of rise Duration Flood seasons Flash flood areas	Technical reports Technical reports Reports Maps
		Legal determinations	Back-up data	Originals or micro-copies
		Educational	Awareness of hazard, program goals and objectives, and hazard mitigation techniques[a]	Personal contact[a], brochures, flood elevations markers on public buildings study report
		Technical assistance	Administrative and regulatory requirements; Selection of floodplain management alternatives; Development of review process; Planning, design, and construction requirements for foundations, supports, and tie downs[a]	Personal contact, technical consultations, and technical reports
FIA and Communities	Land-use regulation	Monitoring, evaluation, and enforcement	Information concerning flood events Hydrologic and hydraulic change; Development pressure	Annual report Annual report statistics, field visits, flood risk shown on deeds, time series aerial photos

[a]Essential needs to be met by FIS.

[b]FEMA map information facility.

[c]Includes wetlands, flood storega areas, key wildlife areas, prime agricultural lands, prime natural resource deposits.

[d]Public safety facilities, utilities, hospitals and nursing home, prisons, shelters, transportation routes, pipelines and refineries, hazardous material production or storega facilities, floatables.

[e]Coordination meetings, seminars, workshops.

[f]Corps of Engineers only.

Appendix B
BIOGRAPHICAL SKETCHES OF COMMITTEE MEMBERS

PATRICIA A. BLOOMGREN, Senior Hydrologist, Division of Waters, Minnesota Department of Natural Resources, St. Paul. Ms. Bloomgren has worked with the Department since 1973. Her major responsibilities have included serving as State Coordinator for the NFIP, Hazard Mitigation Coordinator for flood disasters, and Chairperson of the Association of State Flood Plain Managers. She received a B.S. from Ft. Lewis College and a M.S. in geology from Coloredo State University. She has done additional graduate work and research at the University of Minnesota.

DAVID R. DAWDY, Surface Water Program Manager, Northern Technical Services, Newport Beach, California. Before assuming his present position, Mr. Dawdy was associated with Dames and Moore, Bethesda, Maryland, and served with the U.S. Geological Survey for 25 years. He is a specialist in surface water hydrology modeling and has taught and lectured on the subject both in the United States and abroad. He is a member of the American Society of Civil Engineers, the American Geophysical Union, and the International Association of Hydrological Sciences. Mr. Dawdy received a B.A. in history from Trinity College and a M.S. in statistics from Stanford University.

HOWARD C. KUNREUTHER, Chairman, Department of Decision Sciences, Wharton School, University of Pennsylvania, Philadelphia. Dr. Kunreuther has been Professor of decision sciences since 1975 and the Department Chairman since 1977. His teaching and research interests are primarily operations management and managerial economics. Since 1980 he has been at the International Institute for Applied Systems Analysis (IIASA), where he has been the Task Leader of the Risk Group. He has served with the Disaster Study Task Force of the Office of Emergency Preparedness, with the National Science Foundation on the Natural Hazards Research Project, and as a member of the NRC Committee on Socioeconomic Effects of Earthquake Predictions. He earned his A.B. at Bates College and his Ph.D. in Economics at the Massachusetts Institute of Technology.

MAURICE K. KURTZ, Jr., Associate Professor, Department of Civil Engineering, Florida Institute of Technology, Melbourne. Dr. Kurtz currently is responsible for advanced methods of surveying and mapping and graphics. He formerly served as deputy director and director of the Nuclear Cratering Group at Lawrence Livermore Laboratory, Director of the Defense Mapping school, and director of the Army Engineers Topographic Laboratories. Dr. Kurtz also has taught, written, and lectured widely and worked as a consultant in the areas of remote sensing, hologrammetry, and floodplain mapping. He received his B.S. from the U.S. Military, M.S. from the University of Illinois, and Ph.D. from Purdue University.

RUTHERFORD H. PLATT, Associate Professor, Geography and Planning Law, University of Massachusetts, Amherst. Dr. Platt formerly served as Assistant Director and Staff Attorney for the Open Lands Project. He is a member of the American Bar Association, the Illinois

Bar, and the Association of American Geographers. He received his B.S. in political science from Yale University and J.D. and Ph.D. in geography from the University of Chicago.

ROBERT P. SHUBINSKI, Vice President and Regional Manager, Water Resources Division, Camp, Dresser and McKee, Inc., Annandale, Virginia. Before his death in January 1982, Dr. Shubinski had worked with Camp, Dresser and McKee for 20 years on a variety of water resource management projects and storm drainage, pollution control, and flood control problems. He had worked on projects for NASA, and done studies of Four Mile Run, the Chesapeake Bay, and the Deleware and Potomac river estuaries. He was a diplomate of the American Society of Environmental Engineers, the National Society of Professional Engineers, and the Water Pollution Control Federation. He received a M.S. in civil engineering from Texas A&M University and a Ph.D. in civil engineering from the University of California.

ROBERT L. SMITH, Deane Ackers Professor of Civil Engineering, University of Kansas, Lawrence. Professor Smith, a specialist in engineering hydrology, water resources planning and water policy, assumed his present position in 1970. He formerly served as Executive Director of the Iowa Natural Resources Council, Executive Secretary and Chief Engineer of the Kansas Water Resources Board, Parker Professor of Water Resources and Chairman of the department of Civil Engineering at the University of Kansas, and Technical Assistant in the Office of Science and Technology. He received a B.S.C.E. and a M.S. in hydraulics from the University of Iowa and was elected a member of the National Academy of Engineering in 1975.

W. D. SWIFT, Vice President, Property Claim Services, American Insurance Association, New York, New York. Mr. Swift has held his present position since 1970 and has been associated with the firm since 1959. He formerly worked as Superintendent of Fire and Allied Claims for the Hartford Fire Insurance Company and as Secretary of the North British and Mercantile Insurance Group. Mr. Swift is the author of publications on insurance adjustments and holds a law degree from John Marshall Law School.

FRANK H. THOMAS, Acting Director, Water Resources Council, Washington, D.C. Since 1975 Dr. Thomas has held various policy positions with the Council and has been responsible for various floodplain, and water resource management activities. Formerly he served on the geography faculty and as a department chairman at Southern Illinois University, and as department chairman at Georgia State University. In 1977 he served as the U.S. representative to the United Nations work group that prepared documentation for the UN Conference on Water. He received a B.S. from the University of Illinois and a Ph.D. from Northwestern University.