Department of Public and Environmental Administration

University of Wisconsin-Green Bay

Green Bay, Wisconsin 54302

Natural Hazards and Public Policy: Recommendations for Public Policies to Mitigate the Effects of Natural Hazard Exposures in the United States

December 1978

by

Arthur A. Atkisson, D.P.A.

William J. Petak, D.P.A.

Daniel J. Alesch, Ph.D.

Michael E. Kraft, Ph.D.

David M. Littig, Ph.D.

UWGB Papers in Public Policy and Administration 78-2

REPORT DOCUMENTATION PAGE	1. REPORT NO. NSF/PRA-7509998/6	2.	3. Recipient's Accession No. PB80 187412
4. Title and Subtitle: Natural Hazards and Public Policy: Recommendations for Public Policies to Mitigate the Effects of Natural Hazard Exposures in the United States			5. Report Date: December 1978 6.
7. Author(s): A. A. Atkisson, W. J. Petak, D. J. Alesch, et al.			8. Performing Organization Rept. No. 78-2
9. Performing Organization Name and Address: University of Wisconsin-Green Bay, Department of Public and Environmental Administration, Green Bay, Wisconsin 54302			10. Project/Task/Work Unit No. 11. Contract(C) or Grant(G) No. (C) (G) PRA7509998
12. Sponsoring Organization Name and Address: Scientific, Technological, and International Affairs (STIA), National Science Foundation, 1800 G Street, N.W., Washington, DC 20550			13. Type of Report & Period Covered 14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

A number of analyses are performed as background information to policy plan formulation. A risk analysis considers the natural hazard exposures and losses in the United States. Technology and cost analyses outline hazard mitigation alternatives. Future hazard exposures and losses associated with alternative mitigations are reviewed. Public problems analyses consider the loss experiencing parties, the mitigation-involved parties, the mitigation-constraining parties, and the intrinsic and instrumental candidate public problems. Past and present public approaches to the management of natural hazards are reviewed. Three policy options are offered: a "do nothing" approach, continuing current practices and policies as they are; the initiation of dramatic new changes in current policy; or the concentration of current activities on a "fine tuning" of the current system. Based upon the selection of the third option, a policy plan of seven points is outlined. Recommendations for public policy action are then made for the Federal, state, and local levels of government, as well as for private entities.

17. Document Analysis a. Descriptors

Hazards
Government policies
Local government
Earthquakes
State government
Disasters
Floods

b. Identifiers/Open-Ended Terms

Natural hazards
Hazard mitigation

c. COSATI Field/Group

Availability Statement	19. Security Class (This Report)	21. No. of Pages
NTIS	20. Security Class (This Page)	22. Price

(See ANSI-Z39.18) See Instructions on Reverse

OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)
Department of Commerce

NATURAL HAZARDS AND PUBLIC POLICY:

RECOMMENDATIONS FOR PUBLIC POLICIES TO MITIGATE THE EFFECTS OF NATURAL HAZARD EXPOSURES IN THE UNITED STATES

by

Arthur A. Atkisson, D.P.A.

William J. Petak, D.P.A.

Daniel J. Alesch, Ph.D.

Michael E. Kraft, Ph.D.

David M. Littig, Ph.D.

Department of Public and Environmental Administration

University of Wisconsin-Green Bay

Green Bay, Wisconsin 54302

December 1978

UWGB Papers in Public Policy and Administration 78 - 2

This material is based upon research supported by the National Science Foundation under Purchase Order Number 78-SP-0620. Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

This material is based upon research supported by the National Science Foundation under Grant Number [illegible]. Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

FOREWORD

This public policy analysis is the product of an investigation funded by the National Science Foundation under the terms of Purchase Order 78-SP-0620. The research was conducted by a team of investigators from the University of Wisconsin-Green Bay and Dr. William Petak who was concurrently serving as the principal investigator for a J.H. Wiggins Company natural hazards-oriented technology assessment funded by the National Science Foundation under the terms of NSF grants, ERS-75-09998 and AEN-74-23992.

The purpose of the activities of the public policy team was to provide appropriate policy-related inputs to the J.H. Wiggins Company study and to make appropriate use of the Wiggins-generated data in the public policy analysis. To accomplish these ends, the principal investigator of the Wiggins project (Dr. William Petak) served as a member of the public policy team and as coauthor of the final policy report. Similarly, the principal investigator of the UWGB project (Dr. Arthur Atkisson) served as a member of the Wiggins research team and as coauthor of the final Wiggins project report [Petak, Atkisson, and Glye, 1978].

In a more expansive form, the contents of this report have been included in the Wiggins final project report [Petak, Atkisson, Glye, 1978]. In addition, that report includes extended treatment of the social, technical, administrative, political, legal, and economic constraints on hazard management policy-makers and administrators. It also contains a discussion of the major value issues associated with hazard management policy-making.

In an edited and far briefer version, the contents of this report comprise the substance of a total project summary report for non-technical readers which is being prepared by the J.H. Wiggins Company for the National Science Foundation under the title, "Anticipating the Unexpected: Recommendations for Public Policies to Mitigate the Effects of Natural Hazard Exposures in the United States."

In performing the activities which led to the production of this report, the UWGB policy study team adopted the perspective of an <u>independent</u> team of policy analysts, but we also assumed the role of consultants to the principal

investigator and members of the Wiggins project team. In this regard, the openness, wholehearted cooperation, and responsiveness of Dr. William Petak and other members of the J.H. Wiggins Company deserves special mention. At their own expense, the company agreed to reformat much data, to prepare special data analyses, and even to acquire additional information where we felt a need existed. Our mutual intention was to achieve a fusion of the two study teams, and that fusion did, in fact, take place. As a result, each chapter of the Wiggins final project report contains inputs from the policy team and each aspect of our own report contains inputs and criticisms from their staff. All conclusions and all recommendations in the final project report of the Wiggins Company and of UWGB are the joint products of the two teams.

The extent of the fusion between the two teams also is manifest by the fact that some of the data contained in the loss and cost analysis were developed in Green Bay from raw printouts developed by the Wiggins team, and these data then were confirmed and adopted by the latter. Illustrative are the building damage rates for riverine floodplain sections and the related estimates of losses and mitigation costs which were included in the final Wiggins project report. We borrowed freely from the policy constraint typology (STAPLE) authored by Dr. Petak and we benefited greatly from the descriptive policy research performed by Paul Glye of the Wiggins Company and from the legal analyses performed by other consultants to the company.

Our grateful acknowledgement must be extended to Dr. J.H. Wiggins and Dr. John Collins of the Wiggins Company for the friendly cooperation and assistance we received from them; to Drs. Patrick Johnson and Josh Menkes of the National Science Foundation for their helpful guidance and patience; and to the many others in UWGB, NSF, and the Wiggins Company who contributed in numerous ways to the completion of this project.

I

NATURAL HAZARDS IN HISTORY

Throughout human history hazardous natural events have been the cause of much human suffering and economic loss but have further been the target of much human ingenuity and of considerable activity by government.

At the beginning of recorded history, the early Babylonians were confronted with the hazards posed by intermittent flooding of the fertile plains between the Tigris and Euphrates rivers. Prompted by the need to record and to predict the intermittent episodes of river flooding, the Babylonians developed crude systems of mathematics, laid the intellectual groundwork for the modern field of hydrology, and went on to develop systems of flood control and irrigation works.

Then, as now, the total costs of natural hazard exposures included both the losses sustained as a result of direct exposure of people and property to such events as well as the costs incurred for strengthening buildings, for avoiding high flood-hazard areas, for the construction and operation of flood control and flood-warning systems, and for the development of expanded knowledge concerning the frequency, distribution, magnitude, and effects of natural hazards.

Although occurring much later in history, the experience of North American settlers and their heirs has not been much different from that of the early Babylonians. Although governmental interest in the mounting costs of hazard mitigating policies is of comparatively recent origin, the losses experienced through exposure of people and property to unexpected natural events have been a continuing source of public concern since the first settlers arrived on these shores.

Among the hazards which have produced these concerns are: avalanches; earthquakes; expansive soils; forest, field, marsh, and prairie fires of natural origin; hailstorms; hurricane winds; landslides; lightning; riverine flooding; coastal storm flooding; urban headwater flooding; severe rain, snow, and ice storms; land subsidence; tornados; tsunamis; and volcanic eruptions.

In 1749 Benjamin Franklin invented lightning rods and they swiftly thereafter became standard fixtures on the houses of the westward moving colonial population. However, when the colonial population migrated outward from their original Atlantic colonies they encountered far more than the threat of lightning. In the Great Plains and Midwest States, the colonists confronted the awesome force of tornados and the term, storm cellar or cyclone cellar, became a permanent addition to the national vocabulary. On the open plains of Kansas, Nebraska, and other similar states the typical homebuilder learned early to construct both a regular cellar under the house and an additional cavelike cyclone cellar a few yards from the main structure. Serving as storage areas in tranquil periods, the cyclone cellars provided families with protection against the tornados and severe wind storms that swept across the open prairies.

Twenty-one years before the adoption of the Declaration of Independence, earthquakes shattered Massachusetts, and during the height of the War of 1812, the highest magnitude earthquakes in the history of the nation left parts of Missouri and Arkansas a permanent sunken country. In the immediate post-Civil War years another devastating earthquake struck South Carolina, and in 1871 a forest fire consumed the Wisconsin community of Peshtigo and caused the deaths of 1182 persons. In 1889, high and turbulent floodwaters claimed 2,209 lives in Johnstown, Pennsylvania on a single day, and eleven years later, the largest civil disaster in U.S. history occurred when a "great" hurricane pushed the waters of a storm surge over Galveston, Texas (September 8, 1900) and thereby caused the deaths of 6,000 persons. Only six years later (April 18, 1906) a "great" earthquake rocked San Francisco and, together with the fires which were produced by the event, caused the deaths of 500-700 persons and more than $374 million in property damage. In September, 1928, a Florida hurricane caused 1,833 deaths over a two-day period; the previous March a California dam collapse sent a wall of water over an unwary populace and swept 450 individuals to their deaths.

Many of these pre-1930 natural disasters rank among the most severe civil calamities in our history, claiming more lives per event than the sinking of the Titanic in 1912 (1,517 lives lost); the Texas City ship explosion of 1947 (561 lives lost); the Cocoanut Grove nightclub fire of 1942 (492 lives lost); the Monongha, West Virginia coal mine explosion of 1907 (361 lives lost);

and the worst air traffic accident in history in March 1977 (581 lives lost).

In more recent years, the Palm Sunday tornados of 1965 claimed 271 lives in five states; Hurricane Camille (1969) destroyed over 1.4 billion dollars in property and caused 256 deaths; the South Dakota Flash Flood of 1972 killed 236 persons; the Alaska Earthquake (1964) claimed 131; and Agnes - the Hurricane and Tropical Storm of 1972 - caused 118 deaths and the loss of more than 3.1 billion dollars in property. Also, on a single day in 1974, tornados caused the deaths of 318 persons in several southern and midwestern states.

Less dramatic, but unquestionably of high cost in property damage, have been the week-by-week, and year-by-year losses produced by such hazards as expansive soils and land subsidence and by such events as landslides and the erosion of river banks, lake and sea shores. Periodic droughts, hail, ice, and snow storms also have taken their annual toll.

Public and governmental responses to such occurrences have varied over a broad continuum. Studies performed by other researchers have shown that the immediate aftermath of a severe, disaster-scale event is one which is characterized by high levels of public support for governmental action to avert future disastrous occurrences. Such support may be exhibited both by hazard area residents and by people far removed from the site of the occurrence. Indeed, media exaggerations of disaster impacts increase as a function of distance of the reporting agency from the disaster site and "outsiders" in general, tend both to overestimate the recovery needs of the disaster area and to exaggerate the real impacts of the disaster on the affected communities. Those who did not experience the disaster tend to deny that they too may be threatened by a similar future occurrence on their home turfs ("We don't have floods here; only high water"), but for a while tend to support governmental action to aid those who are less fortunately located.

Within the hazard area, the immediate time period following the occurrence of a severe natural event may be characterized by a high level of public interest in means for averting future disasters and a flurry of public policy proposals may be generated. For example, in the two-year period which preceded

the occurrence of the San Fernando earthquake of 1971, only ten earthquake-related bills were introduced in the California State legislature. In contrast, 47 such bills were introduced immediately following the occurrence of the event, and in 1972 an additional 24 were introduced. Thirty-five of these bills were adopted into law in the post-earthquake flurry of legislative activity, but many were so hurriedly prepared and ill-conceived that substantial amendments to their terms were required in later legislative sessions. Other areas of the nation have experienced similar situations. Between natural disasters, there is generally a lack of public interest in hazard-related legislation and a corresponding lack of legislative activity. However, during the emotional period immediately following a disaster, many hazard-targeted legislative proposals may be advanced and enacted into law, and many of these may be so imprudently drafted as to require later amendments. Moreover, the magnitude and social impacts of the event may be grossly exaggerated.

Depending on the nature of the hazard, the immediate post-event period may see a wide variety of public policy actions. Hillside lots may be zoned so as to limit the use of slide-prone areas by all but the most carefully engineered structures; building code standards may be escalated so as to require new buildings to be resistant to the damage-producing force of winds and earthquakes; hazard warning systems may be inaugurated and population evacuation plans developed; and public investments may be poured into such area protection facilities as dams, seawalls, levees, channel improvements, and revetments. Public funds may be appropriated to aid communities and property owners in restoring their properties after damage-producing natural events have occurred; low cost publicly-subsidized loans and insurance schemes may be provided; and attention may even focus on the strengthening or removal of damage prone structures from high hazard areas.

Interestingly, however, residents in areas which have experienced hazardous natural events tend to deny that such events will occur again. They tend to believe that they will not personally, in the future, experience the adverse impacts of such occurrences. Even new migrants into a high hazard area exhibit this propensity. Although somewhat more fearful than long-time residents, they nonetheless deny that future hazardous events will affect them.

Even in areas which have experienced particularly severe disasters, and where population evacuation systems are the primary means for averting future loss of life, voluntary compliance with evacuation orders tends to drop off as a function of the length of time which has passed since the last severe disaster occurred. Individuals seem to assume either that disastrous events will not recur in the future, or that the impacts of such events will somehow be ameliorated or eliminated by governmental action, that the individual will somehow escape the impacts of such events, and that any personal losses which do occur in the future will be reimbursed to the loss experiencer by some governmental or insuring institution.

In the United States the combined impact of these several factors has been to produce a continuing general increase in the nation's total hazard exposure costs, in the numbers of people and structures exposed to high probabilities of hazardous natural occurrences, and in the proportion of the nation's hazard costs which are distributed to non-risk-taking segments of the population. Continuing increases are being tallied each decade in the dollar value of property lost to natural hazard exposures and in the annual amortized costs of hazard-mitigating measures.

II

THE PLIGHT OF THE PUBLIC POLICY-MAKER

In our efforts to mitigate the effects of exposures to natural hazards rivers have been dammed, deepened and diked. Coastlines have been equipped with sea walls; storm cellars have been dug in backyards; buildings have been elevated above the level of expected flood heights; and a variety of means have been employed to strengthen structures and thereby reduce their vulnerability to the forces exerted by winds, land movement, and other natural hazards. Sadly, however, these efforts have produced somewhat less than fully-satisfactory results.

Construction of flood control facilities has seemed to prompt heavy migration into floodprone areas and has thereby escalated the real costs of flood exposures; governmental provision of disaster relief, low cost loans, and subsidized insurance has seemed to encourage, rather than inhibit, private risk-taking activity. A public unwillingness to acknowledge the threat of future loss-producing occurrences in high hazard areas and an accompanying faith that government will somehow protect them, has contributed to a continuing population movement into such high hazard areas as the hurricane and flood-prone belts of water-adjacent areas along the Gulf Coast and the South Atlantic. Similar population movements have taken place in seismically active areas and along the shores of rivers and lakes subject to periodic flooding. As a result, the nation now faces the probability that one or more major community catastrophes, each far greater in loss of life and property than any which have previously occurred in our history, may occur over the span of the next several decades. But similarly, we also face the risk of over-reacting to the threats posed by natural hazards and the related risk of implementing public policies which may produce costs far in excess of the benefits they'll yield.

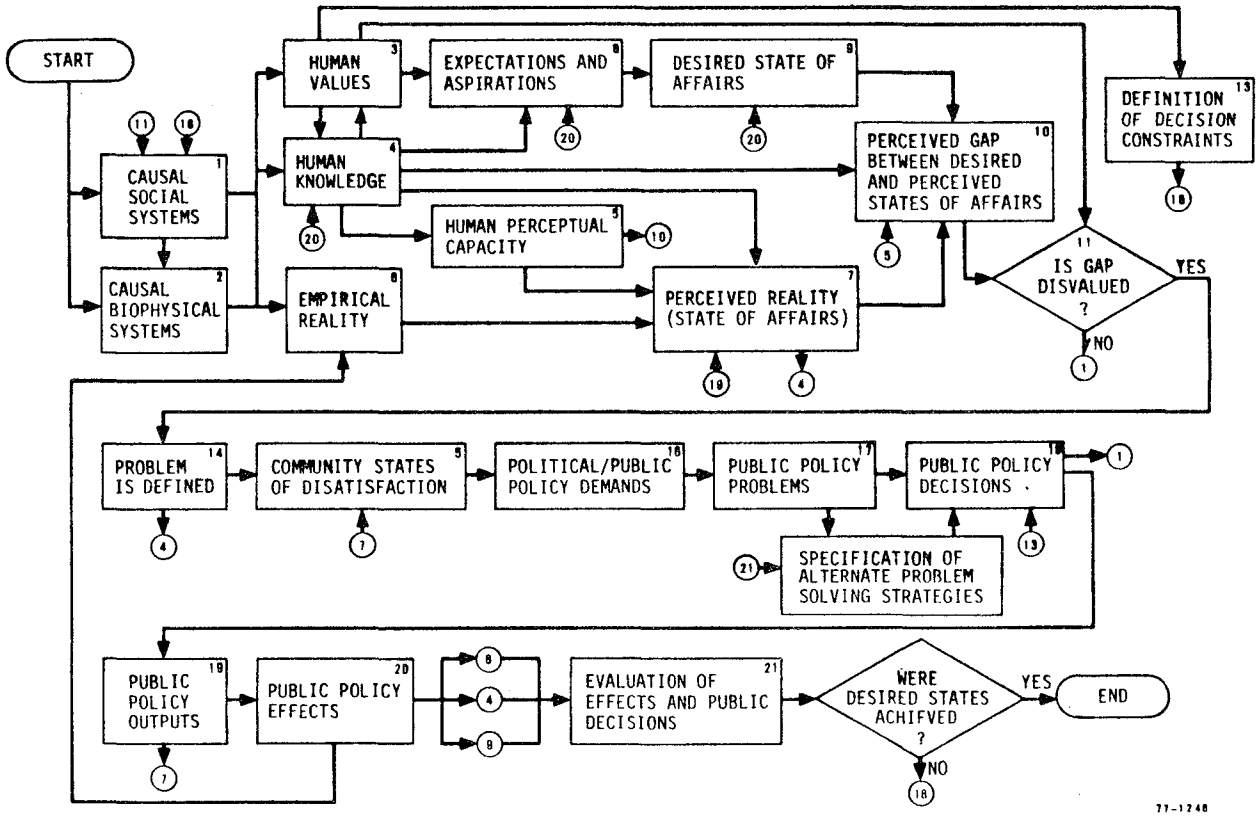
Numerous types of building strengthening, area protection, site development, and other technologies are available for use by those who wish to reduce the risks associated with exposure to natural hazards, and the mandatory applica-

tion of these technologies can be forced through adoption of a wide variety of federal, state, and local public policies.

Hazard-mitigating amendments to building codes, subdivision standards, and land use regulations, can be enacted. Hazard zone identification measures can be adopted, and legally sanctioned systems for avoidance of development in such areas can be inaugurated. The risk of loss may be spread through use of insurance schemes, and the impact of catastrophic hazardous occurrences on exposed populations may be reduced through disaster relief and recovery measures financed by non-impacted parties.

However, every public and private response which can be made to the risks presented by natural hazard exposures imposes costs on someone, somewhere, at some time. In some cases, the costs of such ventures may exceed the value of the risk reduction produced by the purchased mitigation; in still other cases, the use of the mitigation may engender a false sense of public security and lure additional numbers of people into contact with hazardous areas and thereby increase the total losses associated with such exposures. What to do about the continuing exposure of people and property to natural hazards is, therefore, both a question of considerable complexity as well as one of increasing importance to public policy-makers at federal, state, and local levels. Should building code requirements be strengthened? Should governmentally enforced restrictions be imposed on the use of such hazardous areas as floodplains, earthquake-prone sites, and steep hillsides subject to land slippage? What public problems are posed by the voluntary and involuntary exposure of people and property to natural hazards, and what problems might be produced by public efforts to control such exposures? To what extent should those who benefit from governmental investments in hazard-mitigating facilities be expected to bear the costs of those facilities?

Expert observers of the American public policy system have suggested that public problems are the phenomena which trigger the activation and operation of the system. (See Figure 1) However, the situations to which many citizens are so casually prepared to refer as "public problems" can be remarkably difficult for the public policy-maker to define and act upon. For example,


START
HUMAN VALUES 3
EXPECTATIONS AND ASPIRATIONS 8
DESIRED STATE OF AFFAIRS 9
DEFINITION OF DECISION CONSTRAINTS 13
CAUSAL SOCIAL SYSTEMS 1
HUMAN KNOWLEDGE 4
PERCEIVED GAP BETWEEN DESIRED AND PERCEIVED STATES OF AFFAIRS 10
HUMAN PERCEPTUAL CAPACITY 5
CAUSAL BIOPHYSICAL SYSTEMS 2
EMPIRICAL REALITY 6
PERCEIVED REALITY (STATE OF AFFAIRS) 7
IS GAP DISVALUED ? 11
YES
NO
PROBLEM IS DEFINED 14
COMMUNITY STATES OF DISATISFACTION 5
POLITICAL/PUBLIC POLICY DEMANDS 16
PUBLIC POLICY PROBLEMS 17
PUBLIC POLICY DECISIONS 18
SPECIFICATION OF ALTERNATE PROBLEM SOLVING STRATEGIES
PUBLIC POLICY OUTPUTS 19
PUBLIC POLICY EFFECTS 20
EVALUATION OF EFFECTS AND PUBLIC DECISIONS 21
WERE DESIRED STATES ACHIFVED ?
YES
NO
END
77-1248

a situation, impact, or set of effects which may be defined as a problem by one group may be regarded as a solution by another; an effect or impact which may be viewed as a major problem by one group may be viewed as a triviality by another; one person's cost can be another person's benefit; an action which solves one problem besetting a given group may impose yet a different problem on that same group. It is the function of the policy-maker to resolve these dilemmas; to determine whose interests are to be served by public policy - and to what extent - and whose are to be ignored - and to what extent; who is to receive a benefit, and on whom is a cost to be imposed; when it is appropriate to act, and when it is best to do nothing.

Problems do not occur apart from real time and space. They affect real people, at some time, in some real location, under some real condition. However, most problem situations are not well defined; they tend to be characterized by clusters of related phenomena. In such instances, it is necessary to specify candidate problems carefully so that they can be subjected to appropriate analysis and possible corrective action. The problems must be operationalized; that is, they must be defined specifically in terms of what the unwanted attributes of a situation might be and how important those elements may be to specific people in specific places under specific conditions.

Few would disagree that rationally conceived public policies should be targeted on the solution of such problems and that policy-implementing programs should be evaluated, in part, on their success in meeting these policy goals. So it is in respect to natural hazards policy-making and management activities. If public policy-makers at all levels of government are to act with sensitivity and wisdom in fashioning natural hazard management goals, objectives, and programs, then an appropriate base of information must be made available to them.

Good intentions, alone, will not necessarily lead policy-makers to the correct set of answers and problem solutions. Accordingly, appropriate policy-assisting studies performed by others may either be necessary or may contribute to the resolution of the policy-maker's plight. This report is the product of such a set of studies.

Prepared as the summary report of a National Science Foundation funded technology assessment (Grants ERS-75-09998, AEN-74-23992 and Purchase Order 78-SP-0620) the purpose of this report is not to tell policy-makers what public problems are presented by natural hazard exposures in the United States, nor to tell policy-makers what solutions should be applied to such problems.

Instead, its purposes are to present data and factual conclusions which may aid policy-makers in performing this task for themselves; to identify the various stakeholder groups whose interests are bound up in hazard exposure and hazard mitigation situations; to identify candidate lists of possible public problems; to identify the range of technologic and policy options which may be appropriate to solving each listed candidate problem; and to assess the more important costs and benefits associated with each.

Conducted by an interdisciplinary team of investigators, the study utilized risk analysis techniques and resulted in: (1) the generation of annual expected natural hazard loss estimates for 1970 and 2000; (2) identification of specific strategies and technologies theoretically capable of reducing such losses; (3) identification of the amortized annual costs associated with use of selected mitigation strategies; (4) identification of the candidate public problems and stakeholder groups associated with natural hazard exposures and alternative technology-forcing policy options; (5) identification and critical evaluation of past and current public policies, institutional arrangements, and administrative practices aimed at mitigation of natural hazards losses; (6) identification and assessment of the contemporary social technical, administrative, political, legal, and economic constraints on natural hazards policy-making operations; (7) the development and assessment of policy options appropriate for coping with hazard-related public problems between 1970 and 2000.

These study outputs were derived from a project approach which involved four major elements: risk analysis (which included hazard analysis, vulnerability analysis and loss analysis), technology analysis, problem analysis, and public policy analysis. (See Figure 2). These analyses,

which are presented in full in the five volumes comprising the total project report, were used to:

Identify and describe the character, geographic distribution, and potential effects of nine hazardous natural events which occur within the United States (HAZARD ANALYSIS);

Assess the vulnerability of several classes of buildings, and their occupants, to each hazard (VULNERABILITY ANALYSIS);

Identify and measure the major effects associated with the exposure of buildings and their occupants to these hazardous natural events (LOSS ANALYSIS);

Identify and explicate the major candidate public problems associated with these effects (PROBLEM ANALYSIS);

Identify the characteristics of technologies appropriate for mitigating the effects induced by exposure of buildings and building occupants to each hazard (TECHNOLOGY ANALYSIS);

Identify and describe the public policies which may induce the application of hazard-mitigating technologies (PUBLIC POLICY ANALYSIS);

Estimate the economic costs and other effects associated with the use of selected technologies (COST ANALYSIS);

Identify the major effects and candidate public problems which might be generated by the use of these technologies (PROBLEM ANALYSIS); and

Identify and evaluate the major problem-solving strategies and public policies which are relevant to the problems identified in Items 4 and 8, above (PUBLIC POLICY ANALYSIS).

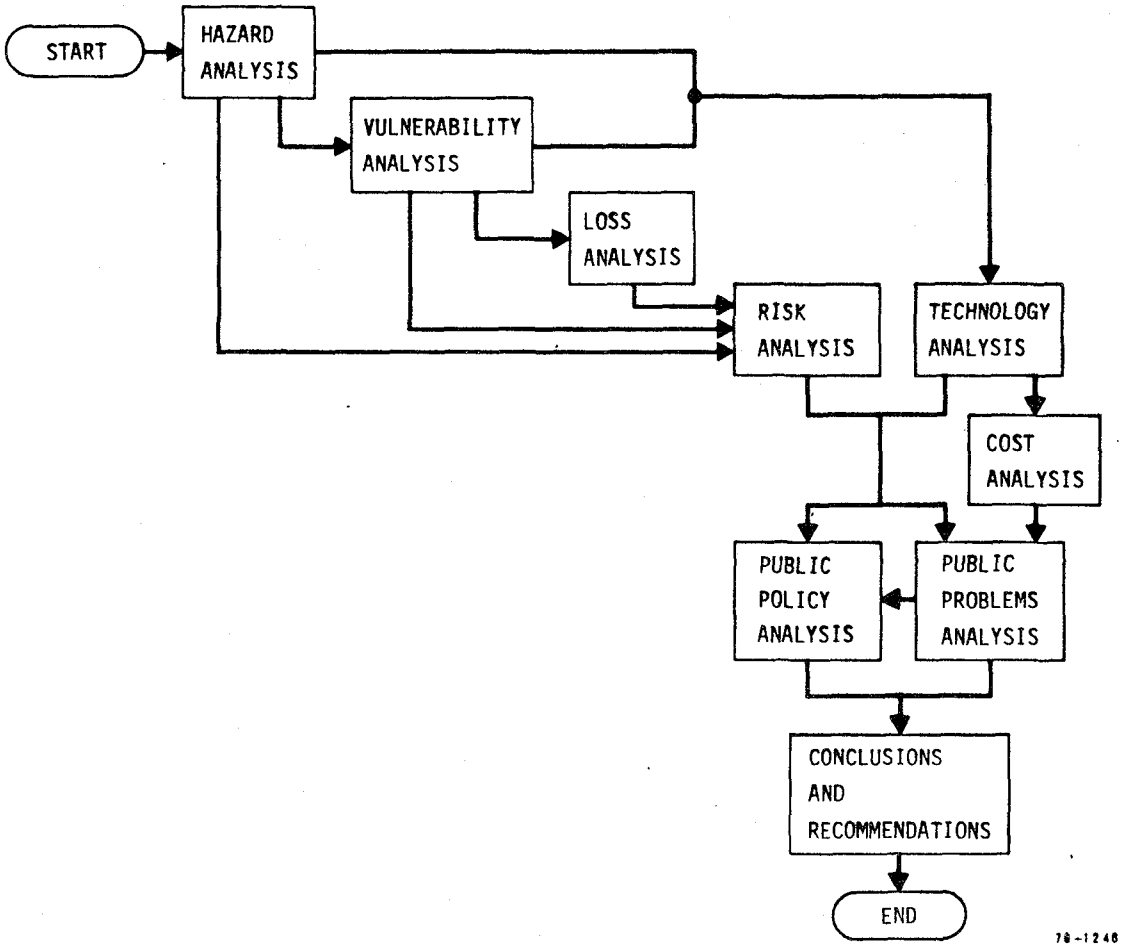


Figure 2 Relationship Between Major Project Activity Elements

In the design of the total study, the investigations were guided by the normative model of an "ideal-type", comprehensive, policy assisting study system which is presented as Figure 3.

The purpose of the normative, or ideal-type, model is to suggest the kinds of reports and analyses which might be prepared by an intendedly value-neutral set of professional analysts in order to assist public policy-makers and others in dealing with the many questions, issues, and decision challenges posed by a complex public problem. Because of the obvious expense associated with implementation of the full model, it is likely that only the most important and socially costly public problems would warrant the formal preparation of exquisitely refined outputs of the many types specified in the model. Certainly, that proved to be the case in respect to this project. Nonetheless, the model did guide the breadth of the analysis and development of content for the outputs associated with each of the project elements depicted in Figure 2.

Although comprehensive in its approach and treatment of natural hazard exposures, this study could not address all of the major probable natural hazard losses in the United States. Therefore, nine hazards were selected for detailed examination: earthquake, landslide, expansive soil, riverine flooding, storm surge, tsunami, tornado, hurricane, and severe wind. This summary report describes the results of that examination.

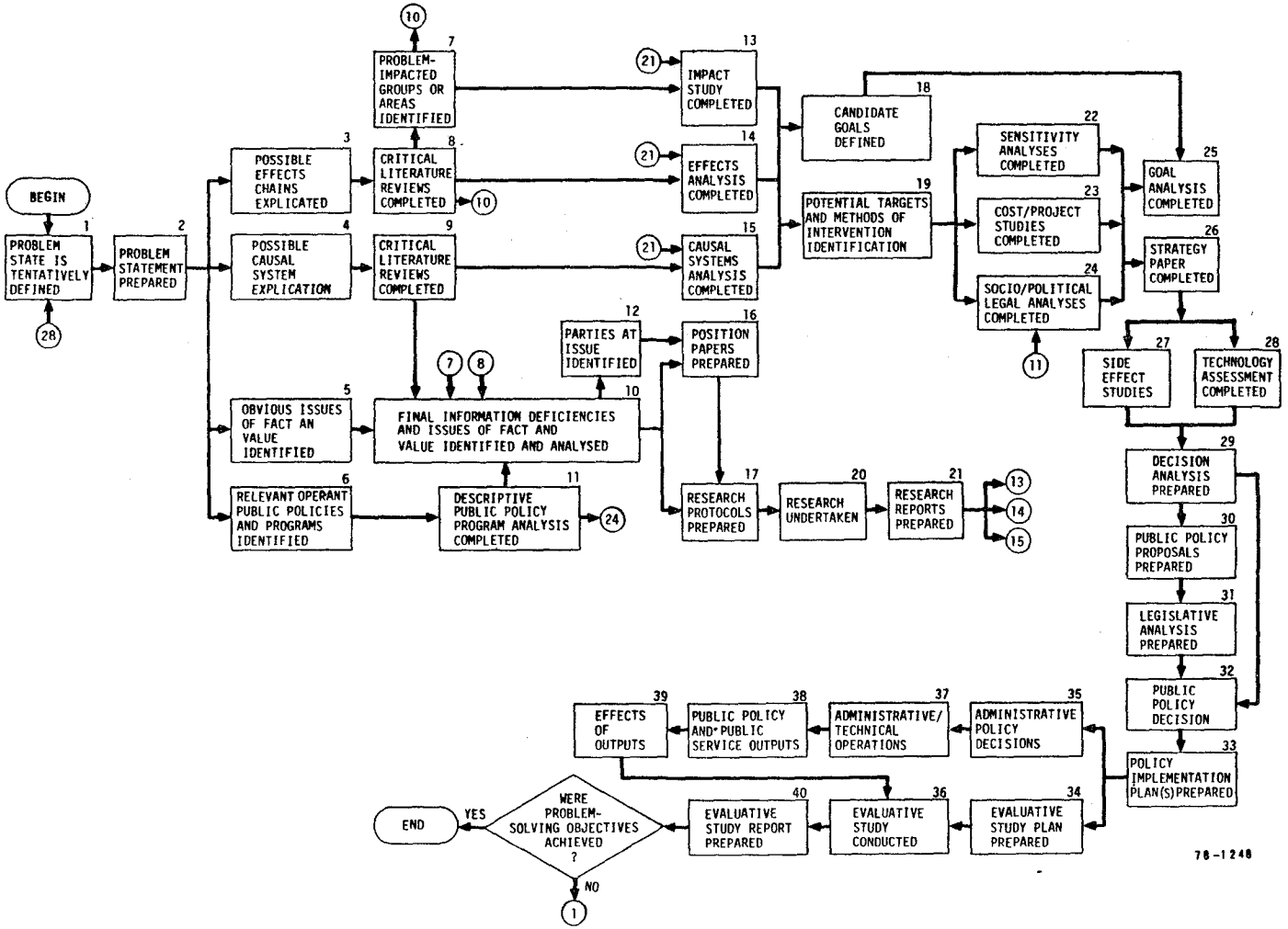


Figure 3 Comprehensive, Value-Neutral, Policy-Assisting Study System

III

THE RISK ANALYSIS: NATURAL HAZARD EXPOSURES AND LOSSES IN THE UNITED STATES

Natural Hazard Exposures in 1970

In 1970, the sizes of the U.S. populations which were at risk of exposure to the nine natural hazards which were the subject of this investigation varied from a low of 109,400 persons in the 100 year tsunami inundation areas to a high of 203.3 million persons in areas subject to severe wind storms. The value of buildings exposed ranged from a low of \$104,670 x 10^6 in county segments subjected to storm surges of 20 feet to 2,064,507 x 10^6 in areas subjected to severe wind storms.

HAZARD	TYPE OF AREA	HUMAN POPULATION EXPOSED		VALUE OF BUILDING EXPOSED TO HAZARD	
		N	PERCENT OF U. S. TOTAL	N ($ x 10^6)	PERCENT OF U. S. TOTAL
1. SEVERE WIND	COUNTIES	203,260,531	100.0	2,064,507.5	100.0
2. TORNADO	COUNTIES	181,198,749	89.1	1,788,989	89.1
3. EXPANSIVE SOILS	FRACTIONS OF COUNTIES			NOT AVAILABLE	
HIGH ZONES		17,730,021*	8.7**		
MEDIUM ZONES		23,710,910	11.7		
LOW ZONES		98,320,710	48.4		
4. EARTHQUAKE ANY INTENSITY	COUNTIES	143,169,495	70.4	1,494,293	72.4
5. EARTHQUAKE	FRACTIONS OF STATES				
ZONE #1		120,600,000	59.3	1,205,138	58.4
ZONE #2		33,340,000	16.4	340,210	16.5
ZONE #3		38,020,000	18.7	427,860	20.7
6. HURRICANE WIND	COUNTIES	62,741,264	30.9	682,476	30.9
7. LANDSLIDE	COUNTIES			NOT AVAILABLE	
HIGH		44,068,071	21.7		
MODERATE		39,426,341	19.4		
8. STORM SURGE	COUNTIES	38,387,247	18.9	438,733	21.3
9. STORM SURGE	COUNTIES SEGMENTS 0-20 FT. MEAN SEA LEVEL (ADJUSTED)	9,940,101	4.89	104,670.25	5.1
10. RIVERINE FLOOD	5,539 FLOOD PRONE CITIES:				
ALL ZONES		24,112,000	11.86	731,977.34	35.5
100 YR. FLOOD PL.		12,056,000	5.93	364,650.79	17.7
50 YR. FLOOD PL.		8,776,416	4.32	265,471.01	12.9
25 YR. FLOOD PL.		5,830,968	2.87	175,478.42	8.5
11. TSUNAMI	100 YR. INUNDATION AREA	109,400	0.054		
	500 YR. INUNDATION AREA	237,500	0.117		
	COUNTIES CONTAINING ABOVE AREAS	18,200,851	8.95	217,327.63	10.5

* Number of People in Single Family Residences

** % of Total Population

Table 1. 1970 Exposure of Building Wealth and Persons to Natural Hazards in the U.S., by type of Hazard

In most cases, these exposures were found to be capable of producing a variety of primary, secondary, and higher order effects, ranging from injury or death to human beings to escalations in the financial overhead burdens of hazard-impacted communities.

PRIMARY EFFECTS	SECONDARY EFFECTS	HIGHER ORDER EFFECTS
1. INJURY OR DEATH TO HUMAN BEINGS	1. HOMELESSNESS	1. UNEMPLOYMENT
2. INJURY OR DEATH TO LIVESTOCK & DOMESTIC ANIMALS	2. SHUTDOWNS OR SLOWDOWNS IN BUSINESS AND INDUSTRY	2. LOSS OF PERSONAL FAMILY INCOME
3. DAMAGE TO STRUCTURES AND THEIR CONTENTS	3. DISRUPTION OF UTILITY SERVICE	3. LOSS OF BUSINESS-INDUSTRIAL INCOME
4. DAMAGE TO COMMUNITY FACILITIES AND INFRASTRUCTURE	4. FINANCIAL EXPENDITURES BY COMMUNITIES, FAMILIES, & BUSINESSES FOR CLEAN-UP & RECOVERY OPERATIONS	4. DIVERSION OF INVESTMENT CAPITAL TO REHABILITATION & RECOVERY PROJECTS
5. DAMAGE TO AUTOMOBILES, BOATS, & OTHER PERSONAL PROPERTY	5. FINANCIAL EXPENDITURES BY COMMUNITIES, FAMILIES, & BUSINESSES FOR REPAIR OR REPLACEMENT OF DAMAGED STRUCTURES, BUILDING CONTENTS, & OTHER PROPERTY	5. ALTERATION OF LAND AND PROPERTY VALUES
6. DAMAGE TO CROPS, FORESTS, AND ORNAMENTAL VEGETATION	6. FINANCIAL EXPENDITURES BY GOVERNMENT FOR REPAIR AND/OR REPLACEMENT OF DAMAGED COMMUNITY FACILITIES & INFRASTRUCTURE	6. ALTERATION OF AREA POPULATION GROWTH TRENDS
7. ALTERATION OF VALUED GEOPHYSICAL CONFIGURATIONS	7. INSURANCE PAYOUTS TO POLICY-HOLDERS	7. ALTERATION OF POPULATION MIGRATION PATTERNS
8. PSYCHOLOGICAL TRAUMA		8. ALTERATION OF COMMUNITY OVERHEAD BURDENS
9. LOSS OF COMMUNITY HOUSING STOCK		9. INCREASED TAX BURDENS TO FINANCE RECOVERY OPERATIONS
		10. ALTERATION IN COMMUNITY SOCIO-ECONOMIC VIABILITY
		11. ALTERATIONS IN FAMILIAL SOCIO-ECONOMIC VIABILITY
		12. DEPLETION OF PERSONAL OR BUSINESS SAVINGS OR CAPITAL
		13. FINANCIAL COSTS TO SUPPLIERS

Figure 4- Taxonomy of Natural Hazard Effects

Natural Hazard Losses in 1970

In quantitative terms, the 1970 effects of U.S. natural hazard exposures were found to be producing annual expected losses of 8.1 billion dollars, 113.9 thousand housing units and nearly one thousand lives.

HAZARD	EXPECTED ANNUAL LOSSES								
	DOLLAR LOSSES RESULTING FROM INDICATED FACTOR (MILLIONS OF DOLLARS)					OTHER LOSSES			
	(1) BUILDING DAMAGE	(2) CONTENTS DAMAGE	(3) INCOME LOSS[a]	(4) SUPPLIER LOSS[b]	(5) TOTAL (1-4)	(6) NUMBER OF DEATHS	(7) HOUSING UNITS LOST	(8) PERSON YEARS OF HOMELESSNESS	(9) PERSON YEARS OF UNEMPLOY.
1. EARTHQUAKE	655.2	123.23	2.651	0.030	781.1	273	20,485	736	413.5
2. EXPANSIVE SOIL	798.1	-	-	-	798.1	-	-	-	-
3. HURRICANE	685.5	267.57	101.803	1.092	1056.0	62	31.885	34,505	21,003.7
4. LANDSLIDES	370.3	-	-	-	370.3	-	-	-	-
5. RIVERINE FLOODING	1901.0	847.02	10.166	0.120	2758.3	190	-	-	-
6. SEVERE WIND	11.4	4.47	2.090	0.022	18.0	5	547	852	373.1
7. STORM SURGE	441.6	197.24	2.367	0.028	641.2	37	24,521	7,290	369.7
8. TORNADO	879.8	469.93	302.821	3.451	1656.0	392	36,212	86,122	57,541.6
9. TSUNAMI	8.7	5.54	0.727	0.012	15.0	20	234	345	97.5
TOTALS	5751.6	1915.0	422.625	4.755	8094.0	979	113,884	129,850	79,799.1

[a] Total loss of worker earnings associated with hazard caused unemployment

[b] Total loss of income experienced by suppliers of businesses and industries experiencing hazard-induced shutdowns

Table 2. Expected Annual Losses from Natural Hazard Exposures in the United States by Type of Hazard and Type of Loss, 1970

In 1970, riverine flooding was responsible for the principal fraction of the annual expected dollar losses. In terms of all hazards, damage to buildings accounted for more than 71.0% of the total annual expected dollar losses.

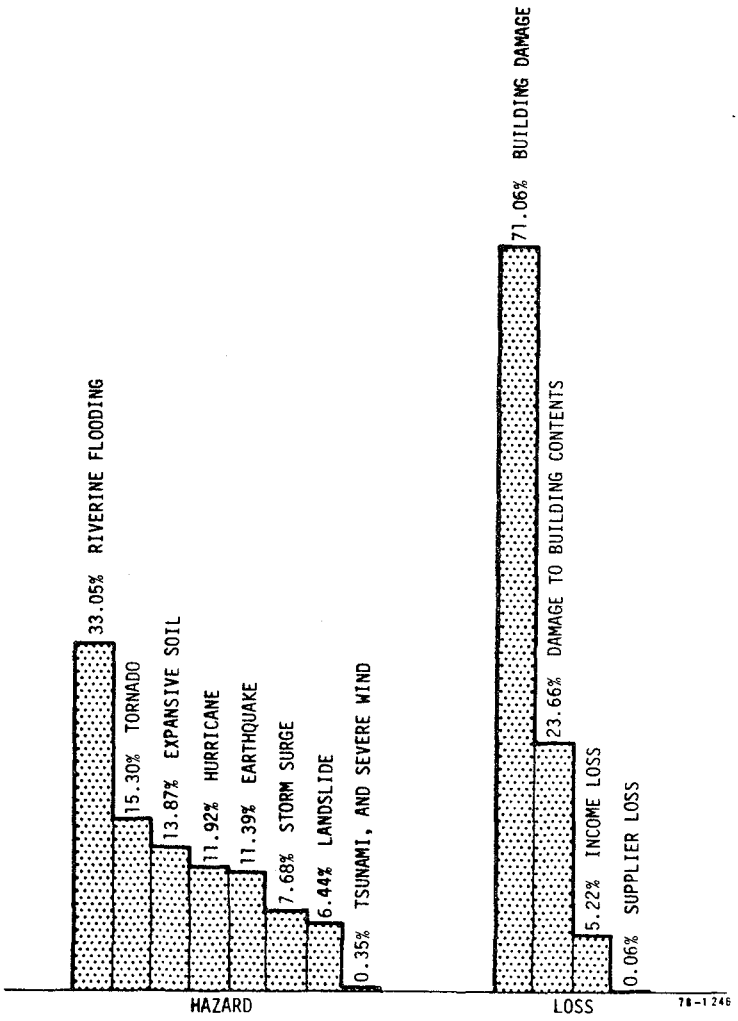


Figure 5 Proportion of 1970 Natural Hazard Annual Expected Dollar Losses Produced by Each Type of Hazard and by Each Type of Loss

In view of the non-uniform distribution of hazardous natural occurrences throughout the U.S. land area, annual expected building damage rates varied widely in 1970 between the several states of the Union and between the several types of hazard zones. Considering the nation as a whole, the 1970 annual expected damage rate for buildings totaled 0.27% of exposed building value.

In contrast, rates for individual states ranged from 0.087% for Washington, D.C. to 0.825% for the State of Florida. Similarly annual expected building damage rates (for all hazards except riverine flooding) for the nation's five hundred most damage prone counties ranged from 0.28% to 3.51%. Containing only 20.4% of the nation's 1970 population, these five hundred counties accounted for approximately 54% of the nation's total building damage losses for all hazards except riverine flooding. Considering the nation's urban riverine floodplains as a whole, annual expected building damage rates in floodprone communities ranged from 0.05% for all areas outside the 100-year floodplain to 2.28% for buildings located in the 2-5 year floodplains of communities not served by such flood protection facilities as dams, levees, and channel improvements.

As a result of these factors, in 1970 fewer than eight percent of the persons in the total U.S. population experienced more than thirty-two percent of the total national building damage economic losses.

EXPOSURE AREA	POPULATION	% OF NATIONAL	LOSS (MILLIONS)	% OF NATIONAL BLDG.DAM.LOSS
RIVERINE FLOOD ZONES A - C	5,830,968	2.87	1438.8	25.02
STORM SURGE INUNDATION AREAS (0-20' MSL, ADJUSTED)	9,940,101	4.89	442.0	7.68
TSUNAMI 500-YEAR INUNDATION AREAS	237,500	.12	8.7	.15
TOTALS	16,008,569	7.88	1889.5	32.8%

Table 3. Hazard Exposure Areas, Population at Risk and Expected Annual Dollar Losses

Moreover, total annual expected per capita losses from natural hazard exposures in 1970 ranged from $16.86 per capita in Vermont for all hazard exposures to the single hazard value shown for the groups depicted in Table 4.

Group	Hazard	Hazard-Specific Per-Capita Loss: Building Damage Only	Hazard-Specific Per-Capita Loss: All Losses
All residents in highest damage rate county of U.S.	All except Riverine Flooding	$219.89	$ 309.44
All residents in 2-5 year floodplains of unprotected floodprone urban communities	Riverine Flooding	$799.75	$1,160.42
All residents in Georgia Coastal Plains at 0.0 to 20.0 feet above sea level (adjusted)	Storm Surge Flooding	$121.37	$ 176.20
All residents in three counties of U.S. with highest building damage rates from tornados and with over 100 tornado strikes annually	Tornado	$ 23.97	$ 45.12
All residents in 500 year Tsunami inundation areas	Tsunami	$ 36.63	$ 63.12
All residents in high expansive soil areas	Expansive Soil	$ 26.00	$ 26.00
All residents in counties having high-risk landslide areas	Landslide	$ 4.25	$ 4.25
All residents in state having highest annual expected damage rate for earthquake	Earthquake	$ 28.42	$ 33.88
All residents in state having highest annual expected damage rate for hurricane wind	Hurricane Wind	$ 28.04	$ 43.20
All residents in state having highest annual expected damage rate for severe wind	Severe Wind	$ 0.30	$ 0.47

Table 4. Per Capita Hazard Losses for Selected Hazards and Populations at Risk

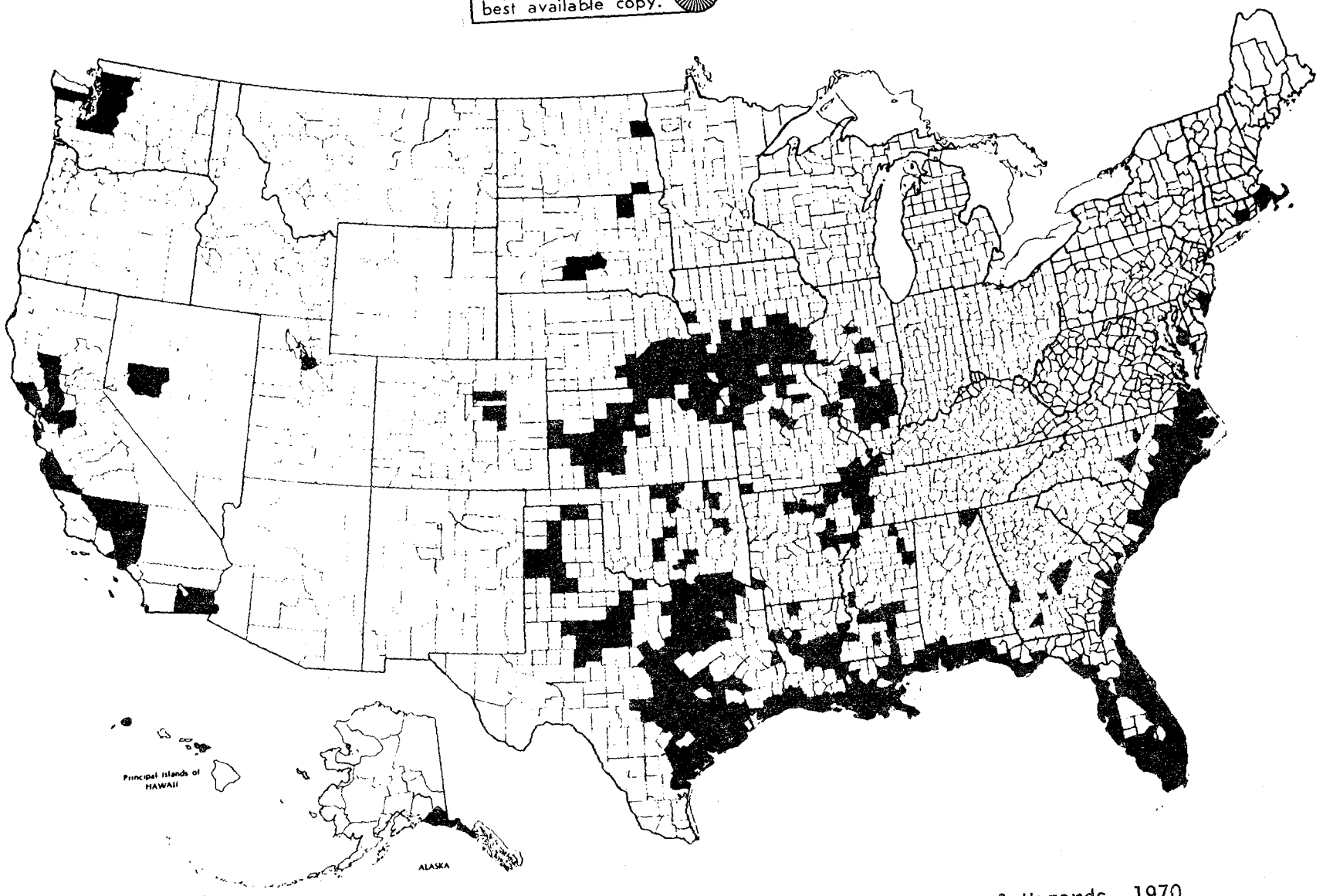


Figure 6 – Map of High Damage Rate Counties for Eight Natural Hazards, 1970

Changes in Hazard Exposures and Losses, 1970-2000

For the thirty-year period between 1970 and 2000, the study showed that annual expected losses from natural hazard exposures will increase by an amount ($9685 million) which exceeds the total estimated loss for 1970 ($8094 million).

HAZARD	EXPECTED ANNUAL LOSSES								
	DOLLAR LOSSES RESULTING FROM INDICATED FACTOR (MILLIONS OF DOLLARS)					OTHER LOSSES			
	(1) BUILDING DAMAGE	(2) CONTENTS DAMAGE	(3) INCOME LOSS[a]	(4) SUPPLIER LOSS[b]	(5) TOTAL (1-4)	(6) NUMBER OF DEATHS	(7) HOUSING UNITS LOST	(8) PERSON YEARS OF HOMELESSNESS	(9) PERSON YEARS OF UNEMPLOY.
1. EARTHQUAKE	1177.0	372.78	3.906	0.048	1553.7	400	22,868	648	634.9
2. EXPANSIVE SOIL	997.1	-	-	-	997.1	-	-	-	-
3. HURRICANE	1742.0	1504.98	276.191	3.095	3526.3	153	52,237	48,271	58,223.7
4. LANDSLIDE	871.2	-	-	-	871.2	-	-	-	-
5. RIVERINE FLOODING	1594.0	1572.54	8.68	.105	3175.33	159	-	-	-
6. SEVERE WIND	24.8	23.8	4.696	0.051	53.4	11	748	1,014	850.9
7. STORM SURGE	1176.0	1160.43	6.407	0.077	2342.9	103	43,757	10,330	1,018.3
8. TORNADO	2058.0	2401.32	750.780	9.042	5219.1	920	52,119	107,650	146,568.5
9. TSUNAMI	19.8	19.10	1.479	0.027	40.4	44	335	389	195.9
TOTALS	9659.9	7054.95	1052.139	12.445	17,779.43	1790	172,084	168,302	207,492.2

[a] Total loss of worker earnings associated with hazard caused disruption
[b] Total loss of income experienced by suppliers of business and industries experiencing hazard-induced shutdowns

Table 5. Expected Annual Losses from Natural Hazard Exposures in the United States, by Type of Hazard and Type of Loss, 2000

These estimated increases in hazard losses are the result of several conditions which we assume will characterize the period 1970-2000: (1) As existing aged buildings are replaced, the average dollar value (in 1970 dollars) of the building mixes in hazard exposure areas also will rise; (2) Under conditions of continued population affluence, the value of contents in the average building will increase when expressed as a proportion of the value of the building; (3) Population growth will continue and interstate migration patterns will be as projected by the U.S. Water Resources Council;

(4) Current natural hazard management policies will remain unaltered and generally will continue to be implemented through the thirty-year period.

Although each of these assumptions was important to the projected thirty-year increase in natural hazard losses, the factors of greatest importance were those related to population growth and future interstate patterns of migration.

If population movements occur in the future as they have in the past, then the high hazard areas of the South Atlantic, the Gulf Coast, and the West will receive great numbers of interstate migrants between 1970 and 2000. When combined with the general increase in the total size of the U.S. population, this population shift will result in a substantial escalation in the nation's natural hazard losses. Because of their higher in-migration rates, the thirteen states which exhibited the highest building damage rates in 1970 will account for approximately 51% of the projected increase in natural hazard economic losses between 1970 and 2000. Unless current public policies are substantially altered, these and other states also will continue to experience high rates of population growth within their intra-state high-hazard areas, such as their riverine and coastal floodplains, slide-prone hillsides, and other similar high amenity but high hazard-potential areas.

Parallelling the projected increase in total natural hazards losses is the projected increase in national per capita losses. These are expected to jump from $39.76 in 1970 to $69.41 in 2000 (in constant 1970 dollars).

HAZARD	Expected Annual Per Capita Loss For Indicated Year	
	1970	2000
1. Riverine Flooding	$13.57	$12.40
2. Tornado	8.12	20.38
3. Hurricane	5.20	13.77
4. Expansive Soil	3.93	3.89
5. Earthquake	3.83	6.07
6. Storm Surge	3.16	9.15
7. Landslide	1.82	3.40
8. Tsunami	.07	.16
9. Severe Wind	.06	.19
All Hazards	$39.76	$69.41

Table 6. Expected Annual National Per Capita Dollar Losses from Natural Hazard Exposures in the United States, by Type of Hazard, 1970 and 2000

Also, the period between now and the turn of the century will witness a substantial increase in our national vulnerability to catastrophic, single year losses resulting from extremely high intensity hazardous occurrences.

Were the "great" San Francisco Earthquake of 1906 to recur in the year 2000 at precisely the same hour and in the same locations, approximately 42 billion dollars in economic losses would occur and approximately 3340 lives would be lost. If the earthquake were to take place at noon instead of the early morning hours, an even greater number of fatalities could be expected...perhaps as many as 10,800 to 40,360. Per capita economic losses would average more than $3000 throughout the 39 county San Francisco Bay area and would exceed $5000 in at least four of those counties.

Were Hurricane Camille to recur in the same Gulf Coast locale in 2000, 28 counties would experience wind and flood damage which would produce an economic loss of approximately $5.9 billion. Moreover, approximately 642 lives would be claimed by such an event, and per capita losses would average $2510 throughout the disaster area, ranging from a high of $16,000 in one county to a low of less than $100 in several others.

The computer models used in this study also revealed that Chicago could experience $3500 million in losses as a result of a Fujita 4 level tornado strike in the year 2000 and that a repeat of Hurricane Agnes (1972) would produce more than one billion dollars in riverine flood losses in a single multi-state region in the year 2000.

Major Conclusions

The data derived from the risk analysis elements of the total study supports six major conclusions:

1. Natural hazard dollar losses are of a magnitude equal to or approaching the costs of other phenomena which generally are viewed as problems in our society.

The nine natural hazards examined in this study produced annual expected dollar losses totaling $8,094.0 million in 1970 and are expected to produce annual losses totaling $17,779.43 million in the year 2000. Representing economic losses sustained by wage earners, suppliers, and the owners of buildings and building contents, these losses exceed the 1970 value of such generally unwanted phenomena as all building losses due to fires, all crimes against property, all expenditures by state and local police departments and the value of all losses resulting from accidents at work. The thirty-year expected increase in annual expected natural hazard losses ($9685 million) approaches the 1970 value of all annual premium payments for health insurance policies. For the nation as a whole, the nine natural hazards considered in this analysis produced annual expected per capita losses of $39.76 in 1970 and will produce expected annual per capita losses of approximately $69.41 in the year 2000. In both years, four of the nine natural hazards account for 72.7% to 77.5% of these losses: riverine flooding, tornado, expansive soil and hurricane.

2. Groups Exposed to Natural Hazards Differ Widely in Terms of the Costs and Impacts Associated with Their Exposure:

Measured by their annual expected per capita losses, comparatively few groups in the U.S. population face large annual losses as a result of their natural hazard exposures.

On a total national basis, the annual expected per capita losses resulting from natural hazard exposures in 1970 and 2000 are not particularly large. For example, the 1970 annual expected per capita loss is $39.76 and is equal to only 1.00% of per capita national income in that year. Assuming 3.2 persons per household, average national household burdens are $127 and $222 for 1970 and 2000, respectively. Such annual losses per household do not appear to be very burdensome, as compared with other major household expenditures.

However, per capita losses vary widely among the several populations exposed to hazards or exposed to the risk of bearing hazard-induced

Table 7. Annual Expected Losses from Nine Natural Hazards in 1970, Compared with Annual Value of Other Types of Losses and Events

TYPE OF LOSS OR EVENT	VALUE IN 1970 (MILLIONS OF $)
1. ALL PROPERTY TAX COLLECTIONS BY STATE AND LOCAL GOVERNMENTS	34,054
2. ALL ACCIDENTS	27,000
3. ALL TRAFFIC ACCIDENTS	16,200
4. TOTAL ECONOMIC EFFECTS OF AIR POLLUTION	16,000
5. HEALTH INSURANCE PREMIUMS	11,546
6. INCREASE IN ANNUAL EXPECTED LOSSES FROM NATURAL HAZARDS, 1970-2000	9,685.4
7. POLLUTION CONTROL COSTS (AIR, WATER, SOLID WASTES)	9,300
8. AUTO LIABILITY INSURANCE PREMIUMS	8,958
9. EXPECTED ANNUAL NATURAL HAZARD LOSSES	8,094
10. LOSSES FROM ACCIDENTS AT WORK	8,000
11. LOSSES FROM AIR POLLUTION-RELATED MORBIDITY AND MORTALITY	6,000
12. AIR POLLUTION EFFECTS ON VALUE OF PROPERTY	5,200
13. AIR POLLUTION EFFECTS ON MATERIALS AND VEGETATION	4,900
14. EXPENDITURES BY ALL STATE AND LOCAL POLICE DEPARTMENTS	4,494
15. ALL CRIMES AGAINST PROPERTY	4,264
16. INVESTMENTS IN WATER POLLUTION CONTROL FACILITIES	3,100
17. BUSINESS LOSSES DUE TO SIX TYPES OF CRIMINAL ACTIVITIES	3,049
18. BUILDING LOSSES DUE TO FIRES	2,209

Sources:

1. The Statistical Abstract of the U.S., Bureau of the Census, Dept. of Commerce, Grosset & Dunlap Publishers, New York 1976. p. 258.
2. Accident Facts, National Safety Council, Chicago, Illinois, Prepared by the Statistics Division, 1971. p. 4.
3. Insurance Facts 1971, Insurance Information Institute, New York. p. 51.
4. Environmental Quality, the Second Annual Report of the Council on Environmental Quality U.S. Government Printing Office, Washington D.C. August 1971, p. 107.
5. The Statistical Abstract of the U.S., p. 484.
7. Environmental Quality, 1971, p. 112.
8. The Statistical Abstract of the U.S., p. 485
10. Insurance Facts 1971, p. 59.
11. Environmental Quality, 1971, p. 106.
12. Environmental Quality, 1971, p. 107.
13. Ibid.
14. The Statistical Abstract of the U.S., p. 258.
15. Insurance Facts 1971, p. 61.
16. Environmental Quality, 1971, p. 112.
17. The Statistical Abstract of the U.S., p. 159.
18. The Statistical Abstract of the U.S., p. 486.

community costs. For example, if all 1970 riverine flood losses are distributed among the members of the population which actually resides in U.S. riverine floodplains, this loss burden would produce an annual expected per capita loss of $114.40 per floodplain resident, or an annual expected household loss of $366.08. Similarly, several million persons in the United States reside in intra-county areas in which they are exposed to a high level of expansive soil hazard and where they will experience annual per capita losses from this hazard totaling $26.00. The nearly 27 million people residing in states exposed to a high level of earthquake hazard are at risk of experiencing an annual per capita loss of $21.27 from this hazard exposure. Residents in the State of Florida, where a comparatively high frequency of hurricane episodes can be expected, were at risk of experiencing 1970 annual expected per capita losses totaling $28.04 for hurricanes and $28.72 for storm surge. In contrast, the 90 million persons residing in states with the lowest riverine flood losses were expected to experience an annual per capita loss of only $7.76 for this hazard in 1970. In terms of the several States of the Union, total annual expected losses for all hazards varied from a low of $16.86 in Vermont to a high of $110.32 in Florida.

When this unevenness in annual expected hazard losses between the several populations at risk is combined with the year-by-year unevenness in actual loss experience, it is clear that personally catastrophic losses from natural hazards may be experienced by numerically significant population subsets in the United States in any given year.

3. Large Year-to-Year Variations in Natural Hazard Exposure Losses Can Be Expected for Most Exposed Groups:

Many of the hazards examined in this study, and for which annual expected damage losses were calculated, may be viewed as comparatively low probability - high consequence occurrences. Thus, hurricane, earthquake, storm surge, and tsunami, accounted for nearly 31% of the annual expected national per capita hazard losses for 1970. However, in any

particular heavily populated area, the probability in any year that a major high intensity event of these types will occur is comparatively small. However, when such events do occur, they are capable of producing losses representing a substantial fraction of the annual income and building value of the impacted area. For example, if a Richter magnitude 8.3 earthquake were to occur in the 39-county San Francisco Bay Area in the year 2000, it could be expected to produce building value losses of $18.155 billion and a total dollar loss of $39.9 billion. Such a loss would be more than double the national, annual, all-hazard expected losses for the same year. Sudden, large magnitude dollar losses of this type may severely impair the recovery capacity of a community, state, or region because of the large short-term demand they make upon available capital and annual incomes. If actuarially sound financial reserves were developed to finance recovery from low probability - high consequence events, then the problems produced by unevenness in annual economic losses could be corrected. In the absence of such systems, however, the uneven temporal distribution of losses must itself be viewed as a potential problem of considerable magnitude.

4. Present and Projected Patterns of Interstate Migration and Capital Investment are the Major Causes of the Large Projected Increase in Natural Hazards Exposure Losses Between 1970 and the Year 2000.

The thirteen states which exhibited the highest 1970 building damage rate for exposure of property to natural hazards will account for nearly 32% of the projected increase in building wealth between 1970 and 2000. In contrast, the thirteen states with the lowest building damage rates will account for only 27% of the projected building wealth increase for the same period. When combined with the higher probability that the population, buildings and other wealth drawn to those states will be at higher risk of exposure to more frequent and higher magnitude hazards, the higher rates of growth in the high damage rate states result in a situation where the high damage rate states of the Union will account for nearly 51% of the increase in annual expected hazard-induced dollar losses which will occur between the year 1970 and 2000.

These loss-increasing interstate patterns of migration are matched by comparable intra-state and intra-county patterns of community development which further exacerbate the economic and other effects of natural hazard occurrences. Continued development of such hazardous areas as those characterized by high soil expansivity, by their location in or proximity to 50 and 100 year floodplains, and by their proximity to areas in which hurricane wind, storm surge and tsunami damages will be experienced simply exacerbate the magnitude of projected hazard-induced dollar and other losses. Large as 1970 annual expected hazard losses may have been, they are dwarfed by the thirty-year increase which is expected to occur between 1970 and 2000. Almost the entirety of that projected increase is unnecessary and avoidable in the sense that hazard-avoidance strategies would, alone, substantially reduce - if not eliminate - those increases.

5. Annual Expected Per Capita Losses from Natural Hazards Generally are Insufficiently High Among Most Exposed Groups to Provide Incentives for Individuals to Make Appropriate Hazard-Avoiding or Hazard-Mitigating Decisions.

In spite of the large estimated total annual losses from natural hazard exposures, and in spite of the fact that some populations at risk may experience burdensome annual per capita losses from such exposures, these per capita burdens generally are insufficiently high to stimulate migrants and investors in property to avoid high hazard areas. In the minds of migrants and investors the natural, climatologic, and other amenities associated with migrant receptor areas apparently outweigh the burdens associated with high hazard exposures in those areas. Although events with low probabilities but high consequences may be most unwanted by loss-experiencers at the time of their occurrence, these same classes of events apparently do not motivate potential risk takers to retreat from situations in which those events may occur. Instead, the largest fraction of the U.S. population apparently draws its motivations from its knowledge of comparatively short-term cycles of events. Thus, such comparatively high probability but low consequence events as structural

fires act as more powerful motivators for personal use of risk mitigating strategies than do such low probability-high consequence events as earthquakes and tsunamis.

6. As Compared with Other Significant Phenomena, Natural Hazard Exposures Do Not Produce High Annual Expected Losses of Lives, Jobs and Homes in Normal Exposure Years.

For 1970, the study revealed that 784 deaths per year could be expected from the exposure of populations to earthquakes, hurricanes, storm surge, tornado and tsunami hazards. For the year 2000, the study revealed that 1620 deaths could be expected each year from population exposures to the same hazards. Even if these annual expected mortality levels were doubled or tripled in order to take account of potential life loss from riverine flooding, the resulting numbers of deaths per year are not impressive as compared with other causes of death within the United States. Thus, for the 15 to 24 year age segment of the U.S. population alone, annual deaths from all accidents total approximately 27,175. Suicide within this same age group results in nearly 4200 deaths per year. In 1970, motor vehicle accidents caused nearly 55,000 deaths among the total U.S. population, and all other accidents were responsible for approximately 60,000 deaths. Diseases of early infancy were responsible for 43,200 deaths in the same year, while cirrhosis of the liver was responsible for 31,400 deaths.

If a large dollar investment is necessary to substantially reduce expected life loss from natural hazard exposures, then it is more than conceivable that a diversion of those funds into other public life-saving strategies would secure even greater annual reductions in life loss. Thus, measured by number of human lives saved per year, there may be substantial "opportunity costs" associated with investment of national resources in hazard-mitigating policies in order to reduce expected life loss from population exposures to natural hazards.

7. Major Catastrophes Associated with Large Losses of Life and Property may be Expected in High Hazard Areas of the United States, with Particular Reference to the Hurricane and Storm Surge Zones of the Gulf Coast and Atlantic, and the Major Earthquake-Prone Metropolitan Areas of the United States.

Chance alone has influenced the fact that no major U.S. city in this century has been struck - full force - with a hurricane of the magnitude of Camille or the devastating impact of the 1900 Galveston occurrence. Chance, alone, has influenced the fact that no earthquakes of the highest magnitude that have occurred in the U.S. in the past 150 years have yet to occur in a large earthquake-prone metropolitan area. Only chance, therefore, has thus far prevented in the current century, the exposure of a large metropolitan-scale population to the kind of devastating, high magnitude, natural hazard occurrence which can be expected to occur once or more in a country of this size and geographic diversity over the period of 100 to 150 years.

When such an exposure does occur, single episode losses in excess of $40 billion can be expected and life loss approaching - or exceeding- 23,000 to 25,000 persons can conservatively be predicted.

IV

THE TECHNOLOGY AND COST ANALYSES: HAZARD MITIGATION TECHNOLOGIES AND COSTS

Introduction

Hazard exposure losses at the high values predicted in this report need not occur in the future; they can be prevented or lessened through use of several types of technologies and through implementation of a variety of public policies. Through the application of hazard avoidance, area structural protection, building strengthening, site preparation, and building removal strategies, building damage losses, alone, may be reduced from projected 2000 values by approximately 41.6%. However, no loss-reducing strategy is completely free from economic or social cost, and over-zealous use of some potential strategies may actually increase total national hazard exposure costs.

Hazard Mitigation Alternatives

Displayed in Figure 7 are the seventeen potential loss-reducing strategies which were examined in detail in this study. Each is capable of being implemented through adoption or amendment of appropriate public investment, land use, disaster assistance, building code, and subdivision policies. Based on their costs and loss-reducing capacities, these alternatives may be grouped into three subsets: (1) those whose use will result in the largest estimated reductions in hazard exposure losses (MOST EFFECTIVE GROUP); (2) those whose application will result in reductions in hazard exposure losses which are at least equal to the annual amortized cost of applying the mitigation (COST FEASIBLE GROUP); (3) those whose application will result in the largest net savings (HIGHEST NET SAVINGS GROUP).

TECHNOLOGY BY CLASS AND TITLE	HAZARD TO WHICH APPLICABLE								
	RIVERINE FLOODING	STORM SURGE	TSUNAMI	HURRICANE	TORNADO	SEVERE WIND	EARTHQUAKE	LANDSLIDE	EXPANSIVE SOIL
1.0 Hazard Avoidance Strategies and Technologies									
1.1 Zero growth on fifty-year flood plains after 1980		●	●						
1.2 Zero growth on 100-year flood plains after 1980		●	●						
1.3 Zero growth on fifty-year riverine flood plains in specified additional numbers of flood-prone cities each year, to 2000	●								
1.4 Zero growth in counties exhibiting high Tornado Strike Risk (greater than 10^{-4} tornado strikes per year per square mile).					●				
2.0 Area Structural Protection Strategies									
2.1 Structural protection (dams, levees, etc) of cities with riverine flood problems.	●								
2.2 Construction of sea-walls to protect four additional counties per year from 100-year storm surge heights. Construct in order of decreasing damages in affected counties.		●							
3.0 Building Strengthening Strategies									
3.1 Require tie-downs on all mobile homes.				●	●	●			
3.2 Increase designed wind resistance capability of new buildings to level equalling 1.5 x the level specified in the Uniform Building Code (1.5 x UBC)				●	●	●			
3.3 Increase designed wind resistance capability of new buildings to level equalling 3.0 x the level specified in the Uniform Building Code (3 x UBC).				●	●	●			
3.4 Increase strength of new buildings to level required in UBC Earthquake Zone #3. (UBC 3).							●		
3.5 Floodproof 2% annually of all structures in fifty year riverine flood plains to provide zero damage to height of four feet.	●								
3.6 Floodproof 2% annually, of all structures in 100 year riverine flood plains to provide zero damage to height of four feet.	●								
3.7 After 1980, floodproof all new buildings in storm surge areas to height of four feet.		●							
3.8 Modify and retrofit existing buildings in high seismic risk areas to meet seismic safety standards.							●		
4.0 Site Preparation Strategies									
4.1 Require soils testing and improved site grading standards in landslide-prone areas.								●	
4.2 Require soils testing and pre-construction moisture control and/or soil stabilization on construction sites.									●
5.0 Building Removal Strategies									
5.1 Purchase and/or condemn and accelerate removal of high vulnerability structures in high hazard areas.	●	●	●				●	●	

Figure 7 Hazard-Mitigating Technologies, by Type and Applicability to Nine Natural Hazards

Detailed examination of the loss-reducing potential of each strategy resulted in the identification of the following set of "most effective" mitigations. Considered collectively, the application of this set of mitigations was found to yield the largest reductions in estimated hazard exposure losses for the year 2000.

HAZARD	MITIGATION
1. HURRICANE WINDS 2. TORNADO 3. SEVERE WINDS	INCREASE DESIGNED WIND RESISTANCE CAPABILITY OF NEW BUILDINGS TO LEVEL EQUALLING 3.0 x THE LEVEL SPECIFIED IN THE UNIFORM BUILDING CODE (UBC). APPLY THE MITIGATION TO ALL NEW BUILDINGS CONSTRUCTED AFTER 1979.
4. EARTHQUAKE	INCREASE STRENGTH OF NEW BUILDINGS TO LEVEL REQUIRED IN 1973 UBC FOR EARTHQUAKE ZONE #3. APPLY MITIGATION TO ALL NEW BUILDINGS CONSTRUCTED IN SEISMICALLY ACTIVE ZONES AFTER 1979
5. EXPANSIVE SOILS	REQUIRE APPLICATION OF CHEMICAL SOIL STABILIZATION TECHNIQUES TO ALL RESIDENTIAL CONSTRUCTION SITES, OR IMPROVED FOUNDATION DESIGN. APPLY MITIGATION TO ALL NEW RESIDENTIAL CONSTRUCTION IN "LOW," "MODERATE," AND "HIGH" EXPANSIVE SOILS ZONES AFTER 1979.
6. LANDSLIDE	REQUIRE SOILS TESTING AND IMPROVED SITE-GRADING STANDARDS IN ALL LANDSLIDE-PRONE AREAS. APPLY MITIGATION TO NEW CONSTRUCTION AFTER 1979.
7. TSUNAMI	PERMIT ZERO NET RESIDENTIAL GROWTH IN TSUNAMI PRONE AREAS AFTER 1979.
8. STORM SURGE	CONSTRUCT SEA WALLS TO PROTECT FOUR (4) ADDITIONAL COUNTIES EACH YEAR FROM 100 YEAR STORM SURGE HEIGHTS. BEGIN CONSTRUCTION IN 1980, IN ORDER OF DECREASING DAMAGES IN AFFECTED COUNTIES.
9. RIVERINE FLOODING	BETWEEN 1970 AND 1980, CONSTRUCT AREA FLOOD CONTROL FACILITIES TO PROTECT 200 ADDITIONAL CITIES EACH YEAR FROM FIFTY YEAR FLOOD LEVELS. THEREAFTER SUSPEND ALL CONSTRUCTION OF FLOOD CONTROL FACILITIES AND APPLY THE FOLLOWING MITIGATIONS: (1) PROHIBIT ALL NET NEW GROWTH IN 100 YEAR FLOODPLAIN: (2) PURCHASE AND REMOVE ALL STRUCTURES FROM 2-10 YEAR FLOOD PLAINS.

Figure 8. Most Effective Mitigation, by Hazard

However, examination of the annual amortized costs associated with each alternative loss-reducing strategy resulted in the finding that many strategies are not cost-effective; their annual principal repayment and annual interest requirements exceed the projected value of their loss-reducing potential. If one is guided in the selection of a mitigation by the criterion that those mitigations should be selected which are both "cost feasible" and which exhibit the largest loss-reducing potential, then the following set may be identified as the preferred choice.

HAZARD	MITIGATION
1. HURRICANE WINDS 2. TORNADO 3. SEVERE WINDS	FOR NEW BUILDINGS CONSTRUCTED AFTER 1979 IN 229 COST-FEASIBLE COUNTIES [TABLE 5-22], INCREASE DESIGNED WIND RESISTANCE CAPABILITY TO LEVEL EQUALLING 1.5x THE LEVEL SPECIFIED IN THE UNIFORM BUILDING CODE. IN THE COST-FEASIBLE SUBSET NUMBERING 72 OF THESE SAME COUNTIES [TABLE 5-22], INCREASE DESIGNED WIND RESISTANCE CAPABILITY TO LEVEL EQUALLING 3.0x THE LEVEL SPECIFIED IN THE UNIFORM BUILDING CODE.
4. EARTHQUAKE	CONTINUE APPLICATION OF UBC EARTHQUAKE ZONE #3 LATERAL FORCE REQUIREMENTS IN ALL CALIFORNIA COUNTIES AND EXTEND REQUIREMENTS TO THE TWO NON-CALIFORNIA COUNTIES IN WHICH THIS MITIGATION IS COST-FEASIBLE [TABLE 5-22]
5. EXPANSIVE SOILS	APPLY CONSTRUCTION SITE MOISTURE CONTROL TECHNIQUES IN AREAS WHERE THE BUILDING SEASON IS MARKED BY WIDE VARIABILITY IN RAINFALL LEVELS
6. LANDSLIDE	REQUIRE SOILS TESTING AND IMPROVED SITE-GRADING TECHNIQUES IN ALL LANDSLIDE-PRONE AREAS. APPLY MITIGATION TO NEW CONSTRUCTION AFTER 1979.
7. TSUNAMI	PERMIT ZERO NET RESIDENTIAL GROWTH IN TSUNAMI PRONE AREAS AFTER 1979
8. STORM SURGE	REQUIRE FOUR (4) FOOT FLOODPROOFING OF ALL NEW STRUCTURES ADDED TO SURGE-PRONE ZONES (20' OR LESS, ADJUSTED MEAN SEA LEVEL) AFTER 1979. CONFINE THE USE OF THE MITIGATION TO THE ONE-HALF OF THE STORM SURGE AREA IN WHICH THIS MITIGATION IS ESTIMATED TO BE COST-FEASIBLE.
9. RIVERINE FLOODING	PROVIDE AREA FLOOD CONTROL FACILITIES SUFFICIENT TO PROTECT ALL FLOOD-PRONE COMMUNITIES FROM FIFTY YEAR FLOOD LEVELS.

Figure 9. Most Effective Cost-Feasible Mitigation, by Hazard

If however, one is guided by the criterion that projected net savings (loss reduction value minus annual amortized costs) should govern the choice of a mitigation, then still another list of loss-reducing strategies emerges as the preferred choice.

HAZARD	MITIGATION
1. HURRICANE WINDS 2. TORNADO 3. SEVERE WINDS	FOR NEW BUILDINGS CONSTRUCTED AFTER 1979 IN 229 COST-FEASIBLE COUNTIES [TABLE 5-21], INCREASE DESIGNED WIND RESISTANCE CAPABILITY TO LEVEL EQUALLING 1.5x THE LEVEL SPECIFIED IN THE UNIFORM BUILDING CODE. IN THE COST-FEASIBLE SUBSET NUMBERING 72 OF THESE SAME COUNTIES [TABLE 5-21], INCREASE DESIGNED WIND RESISTANCE CAPABILITY TO LEVEL EQUALLING 3.0x THE LEVEL SPECIFIED IN THE UNIFORM BUILDING CODE.
4. EARTHQUAKE	CONTINUE APPLICATION OF UBC EARTHQUAKE ZONE #3 LATERAL FORCE REQUIREMENTS IN ALL CALIFORNIA COUNTIES AND EXTEND REQUIREMENTS TO THE TWO NON-CALIFORNIA COUNTIES IN WHICH THIS MITIGATION IS COST-FEASIBLE [TABLE 5-21]
5. EXPANSIVE SOILS	APPLY CONSTRUCTION SITE MOISTURE CONTROL TECHNIQUES IN AREAS WHERE THE BUILDING SEASON IS MARKED BY WIDE VARIABILITY IN RAINFALL LEVELS.
6. LANDSLIDE	REQUIRE SOILS TESTING AND IMPROVED SITE-GRADING TECHNIQUES IN ALL LANDSLIDE-PRONE AREAS. APPLY MITIGATION TO NEW CONSTRUCTION AFTER 1979.
7. TSUNAMI	PERMIT ZERO NET RESIDENTIAL GROWTH IN TSUNAMI-PRONE AREAS AFTER 1979
8. STORM SURGE	AFTER 1979, PROHIBIT NET NEW BUILDING CONSTRUCTION ON THE FIFTY-YEAR FLOODPLAIN
9. RIVERINE FLOODING	AFTER 1979, PROHIBIT NET NEW CONSTRUCTION IN 100 YEAR RIVERINE FLOODPLAINS.

Figure 10. Mitigations Exhibiting Highest Net Savings, by Hazard

Future Hazard Exposure Losses and Costs Associated with Alternative Mitigations

If current policies and practices continued essentially unchanged in the future, annual expected building damage losses will rise from $5.8 billion in 1970 to about $9.7 billion in 2000. If the costs of mitigations are ignored and the "most effective" mitigations are selected, losses in 2000 could be held to approximately $6.4 billion. However, if only cost-feasible mitigations are placed into effect between 1980 and 2000, then hazard exposure losses from building damage will rise to $8.2 billion in 2000, or to about $8.4 billion if the highest level of net savings is selected as the policy goal.

HAZARD	1970 ANNUAL EXPECTED LOSS (MILLIONS $) A	ANNUAL EXPECTED LOSSES IN 2000 (MILLIONS OF 1970$)				
		LEVEL #1 (NO MITIGATIONS) B	LEVEL #2 (EXPECTED LOSSES) C	LEVEL #3 (LOSSES UNDER "MOST EFFECTIVE" MITIGATION) D	LEVEL #4 (LOSSES UNDER "MOST EFFECTIVE" COST FEASIBLE MITIGATION) E	LEVEL #5 (LOSSES UNDER HIGHEST "NET SAVINGS" MITIGATION) F
1. EARTHQUAKE	655.2	1378.5	1177.0	1084.0	1174.3	1174.3
2. EXPANSIVE SOILS	798.1	997.1	997.1	760.1	969.2	969.2
3. LANDSLIDE	370.3	871.2	871.2	349.4	349.4	349.4
4. HURRICANE	685.5	1742.0	1742.0	1280.0		
5. SEVERE WIND	11.4	24.8	24.8	19.1	3217.4	3217.4
6. TORNADO	879.8	2058.0	2058.0	1564.0		
7. RIVERINE FLOODING	1901.0	2634.0	1594.0	953.4	1653.0	1694.2
8. STORM SURGE	442.0	1176.0	1176.0	334.8	826.2	912.8
9. TSUNAMI	8.7	19.8	19.8	19.4	19.4	19.4
TOTAL	5752.0	10901.4	9659.9	6364.2	8208.9	8336.7

Table 8. Annual Expected Natural Hazard Building Damage Losses under Several Alternative Assumptions, 1970 and 2000

When hazard exposure costs are defined as including both the losses resulting from hazard exposures and the cost associated with efforts to mitigate those losses, the total net annual expected natural hazard costs in 2000 could range from $16.9 billion to $37.7 billion.

HAZARD	ALTERNATIVE NO. 1 (DO NOTHING AFTER 1980)		ALTERNATIVE NO. 2 (APPLY "MOST EFFECTIVE" MITIGATION)			ALTERNATIVE NO. 3 (APPLY "HIGHEST NET SAVINGS MITIGATION)		
	A BLDG. DAMAGE LOSS ($MILL.)	B TOTAL DAMAGE LOSS ($MILL.)	C TOTAL DAMAGE LOSS ($MILL.)	D ANNUAL MIT. COST @ 6.0% ($MILL.)	E TOTAL HAZARD COST ($MILL.)	F TOTAL DAMAGE LOSS ($MILL.)	G ANNUAL MIT. COST @ 6.0% ($MILL.)	H TOTAL HAZARD COST ($MILL.)
1. HURRICANE[a]	2,554.46	5,875.3	4,364.3	2,428.3	6,792.6			
2. TORNADO[a]	1,267.2	2,914.6	2,215.2	3,748.8	5,964.0	7,869.76	927.34	8,797.1
3. SEVERE WIND[a]	3.14	7.2	5.6	835.7	841.3			
4. EARTHQUAKE	1,177.	1,553.7	1,430.9	2,549.5	3,980.4	1,550.1	1.42	1,551.5
5. EXPANSIVE SOILS	997.1	997.1	760.1	292.6	1,052.7	969.2	0	969.2
6. LANDSLIDE	871.2	871.2	349.4	0	349.4	349.4	0	349.4
7. TSUNAMI	19.8	40.4	39.6	0	39.6	39.6	0	39.6
8. STORM SURGE	1,176.0	2,342.9	950.23	2,925.6	3,875.8	1,816.5	0	1,816.5
9. RIVERINE FLOOD								
OPTION A	2,634.	5,241.7	1,897.3	12,915.5	14,812.8	3,371.5	0	3,371.5
OPTION B	2,634.	5,241.7	2,465.4	2,094.9	4,560.3	--	--	--
TOTALS	10,699.9	19,844.1	(A) 12,012.61 (B) 12,580.71	(A) 25,696. (B) 14,875.4	(A) 37,708.6 (B) 27,456.1	15,966.06	928.76	16,894.8

a. See discussion in text re: these values.

Table 9. Net Annual Expected Hazard Costs in 2000

The lower figure assumes that present policies toward natural hazard management will be altered during the period 1980-2000 so as to force the use of the "highest net savings mitigations" and includes all losses resulting from natural hazard exposures, as well as the cost of those mitigations. The higher figure assumes that public policies are altered so as to implement the mix of loss-reducing strategies that will produce the lowest ($12.0 to $12.6 billion) hazard exposure losses in 2000. Since these "most effective" mitigations require more costly standards for construction of new buildings and high rates of public investment in area protection works, use of this set of mitigations would actually increase the nation's total national hazard exposure costs above alternative achievable levels in 2000.

On the other hand, the study found a policy of doing nothing more than what is already being done would produce a total annual expected natural hazard cost of $19.8 billion in 2000.

Of course, the above estimates of natural hazard losses and mitigation costs do not place any economic value on the savings in human lives that might result from application of more rigorous hazard management policies. Neither do the cost estimates assume that any national net increase in costs would result from implementation of hazard avoidance policies; the costs associated with the latter are assumed to be primarily distributional and, therefore, of a type where the costs incurred by one party or group are offset by the gains tallied by another party or group.

Clearly, public policy-makers normally consider factors other than economic costs when policies are formulated and implemented. This is particularly true in respect to savings in human lives. However, this study made no attempt to translate into economic terms either the costs or the benefits associated with hazard-induced life loss, injury and illness, homelessness, and unemployment, nor the possible impacts of alternative mitigations on open space availability in urban communities and the possible esthetic and recreational gains (or losses) resulting from use of such mitigations. However, several observations can be made in respect to these matters:

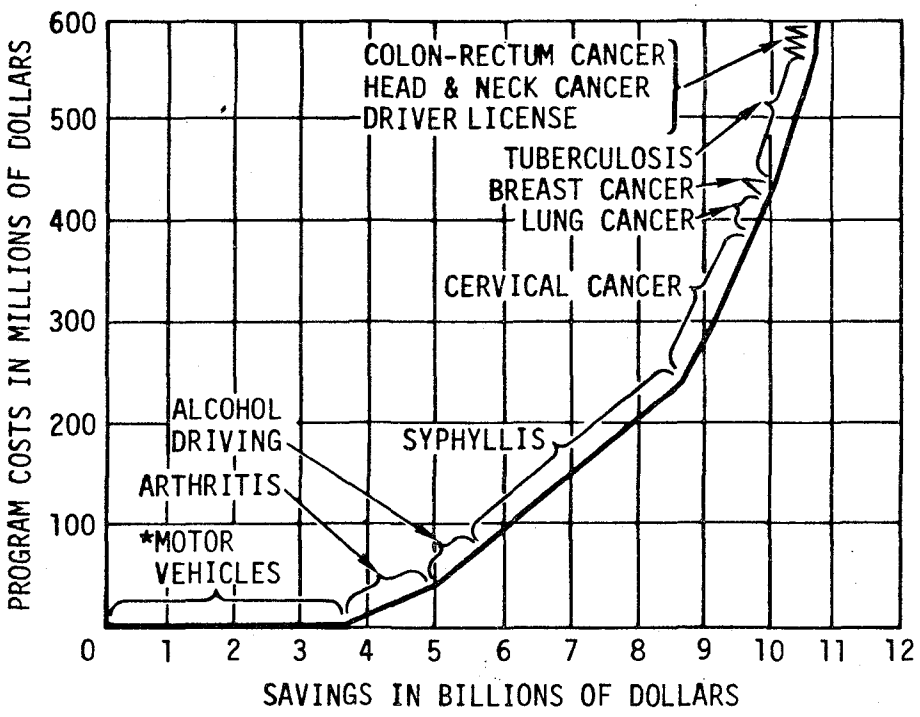
(1) Life Loss:

The procedures used in the study to estimate life loss were based on assumed, but empirically-supported, relationships between the magnitude of dollar loss associated with hazardous occurrences and the loss of life also associated with such occurrences. These procedures resulted in annual expected life loss estimates which were substantially greater for 1970 and 2000 than the annual average life loss for natural hazards which actually has been reported for any of the decades in the current century. Moreover, both hazard induced death rates and the absolute annual average number of deaths from natural hazards has been declining rather steadily throughout the century. Thus, even though the estimates of life loss were probabilistically derived and therefore reflect the intermittent and large losses of life which may be expected from major catastrophes (earthquakes, storm surge, hurricanes, etc.), the annual expected estimates of life loss nonetheless seem to err on the side of overstating the consequences of natural hazard exposures. We believe any such overstatement to be compatible with the objectives of public interest-oriented public policy-making. For example, the Working Group on Earthquake Hazards Reduction (1978) has suggested that "the primary objective of an earthquake hazards reduction program is to save lives," and the United Nations Disaster Relief Office similarly has urged that the highest priority target of national hazards management policies be the protection of human life (1976). Any overstatement of life loss which is a product of our estimates therefore errs in the direction of these ends.

Nonetheless, the annual expected estimates of life loss reported in this study are not impressive as compared with deaths from other causes in our society. Also, efforts to eliminate these losses of life will involve large "opportunity costs."

If one were to make the obviously implausible assumption that the $7,612 million to $17,864.5 million annual escalation in net annual hazard costs resulting from use of the "most effective" mitigations shown in Table 9 would thereby purchase the complete elimination of

all natural hazard deaths projected for 2000 (1861), then the net cost per life saved under this strategy would range from $4.09 million to $9.6 million. In contrast, Gross (1972), has shown that the cost per death averted in four different cancer control programs in the period 1966-1972 ranged from a low of $2217 for uterine cervical cancers to a high of $46,181 for colon-rectum cancers. The cost reduction ratios found by Gross for several public programs are depicted in Figure 11.



SOURCE: Grosse [1972]

*Includes programs on use of seat belts, defensive driving, and reduction in pedestrian injuries

Figure 11 - Dollar Saving in Cancer Programs Compared to Other Treatment Programs

Examination of this evidence suggests that the cost per life saved in natural hazard risk reduction programs can well be escalated to levels substantially in excess of those associated with other death and injury reducing programs which currently may be under-funded.

Although this inference is not intended to suggest that life loss reduction should not be an objective of natural hazard management programs (indeed, we believe the reverse to be true), neither does it seem appropriate to overstate the benefits associated with such programs and to understate the costs associated therewith.

(2) Other Social Costs:

Similar comments can be made in respect to the reductions in homelessness, income, and other psycho-social disbenefits associated with natural hazard exposures. If achievement of a minimum social "pain" level is to be the objective of natural hazard management programs, then it seems clear that hazard zone avoidance policies clearly have the edge over all other strategies. As in the case of life loss, however, it seems clear that the magnitude of these undesirable consequences of natural hazard exposures may easily be overstated. Thus, annual dwelling unit loss associated with highway construction and other public facility construction programs probably is substantially greater than the drawdowns on housing stock which may be charged to natural hazards exposures. Unemployment levels induced by changing Federal Reserve Board policies are substantially in excess of those induced by natural hazards, and federal regulatory policies undoubtedly exert substantially more impacts on supplier costs than do natural hazard occurrences.

Major Conclusions

The data derived from the technology and cost analysis components of the study supports the following major conclusions:

1. Annual Expected Losses from Natural Hazard Exposures in 2000 may be Reduced by More than 40% Through Application of Currently-Available Risk-Reducing Technologies and Policy Mitigations.

Between 1980 and 2000, the application of selected combinations of building-strengthening, area structural protection, hazard zone planning, hazard zone avoidance, and building site preparation technologies can reduce annual expected

building damage losses, alone, from $10,901.4 million to approximately $6,364.2 million (see Table 8). Total annual expected losses may be reduced from $19,844.1 million to $12,012.6 million (see Table 9). This level of mitigation would hold annual expected building damage losses to a value exceeding that of 1970 by only 10.6 percent, in spite of the substantial projected 1980-2000 increases in the size of the population exposed to significant natural hazards.

If mitigation costs are ignored, the largest achievable building damage loss reductions (in millions of $) in 2000 are, as follows: (1) riverine flooding ($640.6 to $1,680.6); (2) storm surge ($841.2); (3) landslide ($521.8); (4) tornado ($494.0); (5) hurricane wind ($462.0); (6) earthquake ($294.5); (7) expansive soils ($237.0); (8) severe wind ($5.7); (9) tsunami ($0.4).

2. Overzealous Application of Strengthened Building Codes and Standards Can Substantially Increase Net Annual Natural Hazard Costs in the Year 2000

The data generated by this study suggests that imprudent and overzealous application of risk-reducing mitigations can increase net annual expected natural hazard costs in 2000 by 38.4% to 90.0% above the levels that will be experienced if current policies remain unaltered. Net annual expected hazard costs are defined as the annualized losses produced by hazard exposures plus the annual amortized costs associated with efforts to reduce those losses.

In terms of the building strengthening strategies examined in the study, in only a comparatively small number of U.S. counties would application of these strategies produce annual loss reductions equal to the annual amortized cost of applying the mitigation at 6.1% interest (see tables 10 and 11).

Only two non-California U.S. counties meet this test in respect to earthquake-related strategies; and only 229 for all wind hazards. In those counties in which loss reduction to cost ratios were 1 to 1 or greater for the "most effective" building mitigation, estimated annual building damage losses in 1970 totalled only 11.08% of all national losses in the same year for all wind hazards, 4.82% for all non-California earthquake hazards, and only 12.5% for all storm surge losses (see Table 11).

HAZARD	TECHNICAL MITIGATION	NUMBER OF COUNTIES IN SPECIFIED CATEGORY OF COST-LOSS REDUCTION RATIOS					
		1-0.75 OR GREATER	1-1.00 OR GREATER	1-1.25 OR GREATER	1-1.5 OR GREATER	1-1.75 OR GREATER	1-2.0 OR GREATER
1. EARTHQUAKE	Imposition of EQ Zone #3 building code standards *1	7	2	2	2	2	2
2. STORM SURGE	Four foot elevation of structure, above flood plain level	24	17	11	8	6	2
3. STORM SURGE	Two foot elevation of structures above flood plain level	30	18	17	12	9	7
4. STORM SURGE	Flood proofing of structures to two-foot elevation above level of flood plain	36	25	18	13	10	8
5. WINDS	Escalation of building code standards to level equalling 1.5 x UBC requirements	250	229	102	76	52	28
6. WINDS	Escalation of building code standards to level equalling 3.0 x UBC requirements	104	72	28	20	16	12

*1 Does not include California counties, since these standards already are enforced there

Table 10. U.S. Counties, Classified by Cost-Loss Reduction Ratio Associated with Selected Natural Hazard Technology Mitigations, 1980-2000

HAZARD	MITIGATION	NUMBER OF COUNTIES WITH SAVINGS-COST RATIO OF 1:1 OR GREATER	1970 VALUE OF STRUCTURE WEALTH AT RISK (MILLIONS $)	DAMAGE RATE AT MID-POINT OF RANGE FOR COUNTIES IN CLASS	ESTIMATED ANNUAL BUILDING LOSSES, 1970 (COLUMN 3a COLUMN 4) (MILLIONS $)	ESTIMATED VALUE OF NEW CONSTRUCTION 1980-2000 (MILLIONS $)	COST OF MITIGATION, 1980-2000 (MILLIONS $)	COST OF MITIGATION, 1980-2000 (MILLIONS $)	TOTAL 50 YEAR LOSS REDUCTIONS EXPECTED FROM USE OF MITIGATION (MILLIONS $)	NET 50 YEAR SAVINGS EXPECTED (MILLIONS $)	50 YEAR SAVINGS AS PERCENT OF CUMULATIVE BUILDING VALUE (MILLIONS $)
****	UBC ZONE #3 STANDARDS	2	307.6	0.03340	10.27	749.00	22.5	22.5	85.2	62.7	8.37%
	4 FT ELEVATION OF STRUCTURES	17	4,957.9	0.01115	55.28	13,096.36	2,173.0	2,173.0	3,169.0	996.7	7.61%
	2 FT ELEVATION OF STRUCTURES	18	5,519.4	0.01445	79.76	14,689.00	1,939.0	1,939.0	3,287.0	1,347.0	9.17%
	2 FT FLOODPROOFING	25	23,351.3	0.00588	137.19	69,871.79	8,175.0	8,175.0	10,360.0	2,170.0	3.1%
	1.5 UBC	229	200,100.0	0.00213	425.21	475,428.57	9,984.0	9,984.0	16,710.0	6,729.0	1.13%
	3.0 UBC	72	54,650.0	0.00339	185.26	156,549.00	7,984.0	7,984.0	13,850.0	5,598.0	3.58

*Defined as Savings-Cost Ratio of 1:1, or greater
no California counties are included

Table 11. Selected Data for Counties in Which Fifty-year Loss Reduction from Use of Natural Hazard Structural Mitigations is Equal to or Less Than the Cost of Applying the Mitigation*

In respect to riverine flooding, risk-reducing mitigation strategies which involve both the provision of area protection against fifty-year flood heights and requirements for four-foot floodproofing of all structures in fifty-year flood plains do not appear to be cost-feasible. Similarly, the elevation or flood-proofing of all new structures in counties influenced by storm surge flooding does not appear to be economically feasible, but such strategies are feasible in sections of the coast lying below 20.1 feet, adjusted mean sea level.

Although building-strengthening strategies clearly are important loss-reducing tools, the study suggests that these strategies should not comprise either the whole or even a significant fraction of the nation's natural hazards management policy. Indeed, study findings contain within them the "hint" that current model building code requirements may well exceed economically justifiable levels if applied in numerous counties of the U.S. Examination of this possibility was beyond the scope of this project but seems clearly to be a subject worthy of future investigation.

3. Riverine and coastal area flood control facilities constructed in compliance with post-1936 economic criteria appear to be cost-effective methods for controlling losses at specified levels of hazard zone occupancy, but contribute to temporal increases in annual expected losses within the hazard zones.

For the overwhelming fraction of the current century, the construction of area protection facilities (dams, levees, seawalls, etc.) has, together with warning and population evacuation systems, comprised the primary U.S. public policy approach to the mitigation of risks associated with riverine and coastal flooding. Based on the crude cost-feasibility tests applied to this policy in this study, it appears that--at the national level--the following conclusion is warranted: under a condition where community values decree that flood-prone lands are to be developed to the level currently exhibited by the sum of U.S. flood-prone urban communities, then the provision of these facilities seems to be cost-feasible, at 6.0% interest; viz. The annual loss reductions under conditions of development appear to be more than the annual

amortized cost of the facilities. Optimistically, net annual savings from sea-wall protection of surge-prone coastal areas may be as high as $480 million per year in 2000. In 1970, annual net savings from construction of all prior riverine flood control works may have been as high as $595 million; and 1970-2000 investments in flood control works for 4,418 flood-prone communities could produce annual net savings in 2000 of approximately $570 million (at 9.0%) to $1,400 million (at 6.0%).

These estimates should be viewed as optimistic. They do not consider such potential disadvantages as ecological damage and the increase that might result in the absolute number of persons exposed to the hazards of dam failure and flood heights above the fifty-year level. Neither do they consider the possible downstream increases in water volumes resulting from higher runoff and lower water retention in flood-protected areas. Also, although tests of feasibility were based on both 6.0% and 9.0% interest levels, future annual net savings were not discounted to their current value. Also, the application of this strategy does not appear to be generally cost-feasible when combined with a flood plain avoidance strategy for new construction and--if applied alone--would result in temporal increases in absolute annual losses from flooding.

4. The large "opportunity costs" associated with application of "most effective" mitigations (see Figure 9) suggest that the use of such mitigations is not an economically justifiable approach for curbing the life-loss associated with natural hazard exposures.

Even though the life-loss estimates generated in this study are on the side of overstating this consequence, annual expected life-loss resulting from natural hazard exposures is not high as compared with other causes of controllable premature death in U.S. society. Moreover, the use of "most effective" natural hazard mitigations--even under implausibly optimistic assumptions concerning their death-reduction effectiveness--results in extraordinarily high costs per death averted.

If a paramount objective of the total mix of national-level policies concerning environmental quality, work-place safety, natural hazards, and public and environmental health is to achieve maximal reduction in deaths

from these causes at any constrained annual level of public and private investment, then other causes of premature death would warrant a higher policy priority. This conclusion seems justified even if the deaths-avoided findings are doubled and costs of death aversion are halved for the "most effective" natural hazard mitigations.

Also, logic suggests that hazard zone avoidance, hazard warning, and population evacuation systems and policies would prevent more hazard-related deaths than the across-the-board application of the "most effective" mitigations identified in this study.

5. Even if the occurrence of a high magnitude natural disaster is assigned a probability of "one" for a major metropolitan area, the community application of the "most effective" mitigation for reduction of losses from such single episodes does not appear to be cost feasible.

If one knew with absolute certainty that a Camille-magnitude hurricane would strike a given community in a given year, community application of the "most effective" mitigation available to minimize losses would not be cost feasible. At a 6.1 percent interest rate, 4-foot flood proofing of new structures in surge-prone areas and imposition of wind resistance standards equal to 3 x UBC on new structures produce annual amortized mitigation costs which are nearly double the annual, non-discounted value of the anticipated single-episode loss reductions. Also, the annual amortized mitigation costs equal $255 per capita, about 4.0 percent of the per capita income, and exceed - by 50% - the normal annual per capita costs of municipal services.

In respect to new structures in an area subject to a "great San Francisco"-magnitude earthquake, a doubling of the lateral force specifications contained in the 1973 Uniform Building Code for earthquake zone three structures produces annual amortized mitigation costs (at 6.1%) of $269, a value which is equal to 3.2% of per capita income and is more than 50% above the annual per capita costs of all municipal services. These annual costs are in excess of expected annual loss reductions by a factor of 3.

This conclusion does not mean to suggest that only economic criteria be employed in the mitigation decision making process; but does suggest that decisions by higher levels of government may suppress local determination regarding the issue of making the severity of the regulation conform to the severity of the risk. Specifically, the potential for a large episodic loss, both economic and social, exists in many areas of the country; and all areas are not uniformly susceptible, nor will all communities place the same value on a given level of susceptibility. Accordingly, policy-makers may wish to preserve the opportunity for local assessment of risk and for differential weighting of tests of cost feasibility.

V

PUBLIC PROBLEMS ANALYSIS: THE STAKEHOLDERS

The interests of several distinguishable groups, or stakeholders, are involved in the many kinds of situations in which the above-described exposure losses and mitigation costs occur, or in which these losses and costs are transferred to non-exposed parties. In general, these stakeholders may be grouped into three classes: loss experiencing parties; mitigation-involved parties; mitigation-constraining parties.

A. Loss-Experiencing Parties

Stakeholders in this class include all of those groups which bear the losses arising from natural hazard exposures and/or the costs arising from efforts to mitigate the effects of such exposures.

1. Residents of Natural Hazard Zones

For each of the nine natural hazards identified in this study there is a companion set of identifiable hazard zones within the United States, the residents of which may be viewed as being at risk of experiencing the consequences associated with the occurrence of the hazard. The sum of the individuals who reside, who own property, or who have other financial interests within these zones may be viewed as constituting the current population at risk of exposure to hazardous natural events. (see Table 1). This major stakeholder group consists of at least two component sets of parties: (a) individuals who currently are exposed to the hazards as a result of voluntary choice on their part, and (b) parties who are involuntarily exposed to the hazards. The former group includes those who, having knowledge of the fact that they were entering into or remaining within a hazard zone, nonetheless chose to do so; while the latter includes parties who: (a) either entered into or are remaining in the hazard zone out of ignorance concerning the risk they are running, or (b) are aware of the risk they are running but lack an ability to remove themselves from the hazard zone because of such factors as the demands of their employment or their financial inability to move elsewhere.

No independent research was conducted by the study team to assess the quantitative size of these two types of risktakers in respect to any hazard zone. However, other research suggests that substantial numbers of individuals who are at risk of exposure to hazardous events are ignorant of the risk they are incurring. Thus, studies by White, et al. [1958], Kates [1971], Roder [1961], and Burton, et al. [1965] suggest that a significant fraction of occupants of riverine flood plains are comparatively unaware of the risks they are running and of the adjustments they may make to reduce those risks, whereas residents of coastal areas exhibit comparatively good knowledge of the risks they are running and of the effects of past storms. Mileti, Drabek, and Haas [1975] suggest that "most persons simply do not know the character and extent of the hazard (s) for the area in which they reside or work." They further comment that "realtors and civic leaders tend to suppress discussion of flood hazards, refuse frequently to recognize, even privately, the dangers of encroaching development, and sometimes reject flood protection works to avoid admission of the hazard's existence." Although much more needs to be known concerning this subject, it seems safe to state, especially with regard to less studied hazards (i.e., expansive soil), that comparatively few occupants of significant hazard zones are fully aware of the magnitude of the risks they are incurring and of the adjustments which they may make to mitigate those risks. Similarly, it seems clear there is little impulse on the part of sellers and transferors of property to inform property purchasers and users of the risk they are running by locating within a hazard zone.

The threat of a substantial loss of property or life is faced by occupants in many hazard zones, such as high-frequency coastal and riverine flood plains, tsunami inundation zones, and tornado-prone areas. Expansive soils, landslides, earthquakes, and other hazards all exhibit varying annual expected loss burdens to occupants of the appropriate hazard zones. However, hazard zone occupants who have experienced the consequences of hazardous occurrences do not--in any great numbers--exhibit a willingness to remove themselves from the hazard zone. Instead, they wish to get on with life as it was before the event occurred, tend to deny that a recurrence of the event will heap any substantial consequences upon them, and seek support from government

and other parties to make the area "safer" should the future bring a recurrence of the event.

Personally catastrophic losses may befall both voluntary and involuntary risktakers within natural hazard zones, and there is undeniable historic evidence that such risktakers have a strong propensity to seek means for externalizing those cost burdens. For comparatively few hazards is insurance available to "spread the risk" of loss among the national or regional pool of hazard-specific risktakers. However, even when insurance is available there are comparatively few takers for the service, either because of the cost of the insurance or because of a persistent tendency of hazard zone risktakers to deny that adverse consequences will befall them. Although federally subsidized flood insurance has substantially increased the number of holders of this type of policy, it is clear that far fewer occupants of flood zones opt for this protection than economic wisdom might lead a neutral analyst to predict.

2. Potential Future Residents of Natural Hazard Zones.

However large the size of the current population at risk of exposure to natural hazards, current patterns of migration and rates of population increase suggest that the size of the hazard-exposed population in 2000 will be substantially greater than at present. Indeed, the projected increase in annual expected natural hazard losses for the period 1970-2000 is greater than the total estimated losses for 1970.

Three demographic facts about the U.S. population suggest the quantitative importance of this stakeholder group: (1) the population is growing older and the proportion of the population above the "working age" is increasing; (2) the population, in all age groups, is increasingly mobile and given to comparatively frequent changes in their place of residence; (3) much interstate migration has been occurring, particularly from inland to coastal and from cold weather to warm weather climates.

A large fraction of the mobile portion of our national population may, and are, being attracted to those high hazard areas and zones which exhibit a

higher than normal mix of biophysical and recreational amenities. Precipitous and slide-prone slopes may offer occupants stunning vistas of cities and natural terrain; coastal and riverine flood plains may offer relief from the congestion and polluted air of cities and easy access to water-based recreational activities; areas of high seismic activity may offer scenes of mountain vistas and easy access to a variety of recreational areas. Although lured by the amenities exhibited by "high hazard areas" the migrant may lack knowledge concerning the characteristics of the hazards within the area and the magnitude of the risks which are incurred by occupants within those areas. Similarly, the types of adjustments which may or should be taken by hazard zone occupants may be totally unknown to such individuals. The conviction that a benevolent and all-knowing government will protect the citizen from harm may dampen the concern of those who have some meager knowledge of the hazards associated with a potential living or working place, and such groups may find it inconceivable that the government would permit their entry into areas where there are substantial risks.

The findings which led to the adoption of the Interstate Land Sales Act might well be considered as evidence in support of the assumptions offered above. Numerous property transactions are made within our society by parties who, imprudently and at great risk to themselves, place their faith in the integrity of land developers and property sales enterprises.

Of course, the interests of this stakeholder group involve more than the threat of loss from involuntary entry into high hazard areas. Their interests extend also to choice-inhibiting public policies which might: (a) prevent their voluntary and knowledgeable entry into high amenity areas in which greater-than-normal natural hazard risks may be present, or; (b) require the use of building strengthening mitigations and thus escalate the cost of structures within such areas.

It seems likely that no single proposed criterion for trading off the risks of hazard exposure against either the cost of building mitigations or the amenity returns derived from entry into some areas will satisfy all members of this group.

3. Visitors or Workers in Natural Hazard Zones

Hospitals, nursing homes, and places of work or entertainment draw hundreds of thousands of transients into potentially hazardous areas during selected hours of the day or periods of the year.

Although the permanent resident population of U.S. central cities has been declining, it is very likely that the daytime worker, shopper, and visitor populations of these same places have been increasing. Workers, shoppers, and tourists clog the streets of major central business districts during daytime hours throughout the nation, while conventioners, theatergoers, window-shoppers, and urban entertainment seekers may be found in great numbers in the same places during the evening hours.

Most of the deaths produced by the San Fernando earthquake of 1971 occurred within a Veterans Administration hospital whose occupants were drawn to the facility out of a concern for, rather than a rejection of, interest in their own longevity.

Scenarios depicting the plight of the above population subsets are not difficult to write. Surrounding the high-rise megastructures of many cities in seismically active areas are literally thousands of individuals clogging the streets during the noon hour. Imagine a high magnitude earthquake which rocks and stresses the structures, releases parapets from their mountings, shatters the acres of glass enclosing the buildings and sends tens of thousands of sharp and heavy missiles down upon the unwary population below. Or, imagine the hikers and campers in the inundation area below Teton Dam in Idaho at the time of the dam failure there; or the vacationers jammed into a seashore hotel in a tsunami inundation area. There is no end to the examples one may cite.

Ignorance of their risktaking, trust in the protecting influences of government, and a concern for the objectives and interests of the moment are more likely the concerns and perspectives of this group than the manipulation of some risktaking calculus.

4. Owners and Users of Second Homes in Natural Hazard Zones

In recent years both the absolute and proportionate numbers of second homes in the United States have been on the increase. Increased affluence among some segments of U.S. society and increased discretionary income have fueled this trend.

Much of this second home development has occurred in high hazard areas, such as the coastal flood zone. Members of the study team have examined, on-site, several colonies of second home developments along the Gulf Coast. One such colony, located on the Bolivar Peninsula near the Houston metropolitan area, is in a site which has been subject to frequent devastating storm surges and hurricane winds. The major fraction of the developed properties were given over to "weekend" and vacation cabins, virtually all of which were elevated several feet above ground level. Most, however, were observed to be of structurally inferior construction with large spans between floor joists, unfinished interior walls, poor wiring, and blessed by a minimum of structural amenities. Although no scientific sample of cabin owners was drawn in this colony, discussions with several indicated their keen awareness that their properties were located in a high hazard area and most reflected little concern over this fact. The typical view was "when the next hurricane strikes, we'll simply rebuild." Several expressed the view that low-cost loans from the government would aid them in the venture, and several indicated that their existing cabins had been constructed in part with debris scavenged from the area after the last destructive storm.

5. Non-Risktaking Bearers of Natural Hazards Costs

A significant fraction of the losses produced by exposure of people and property to natural hazards is now being transferred to non-exposed populations in the form of tax levies. These levies are destined to finance government-provided relief, recovery and insurance services to the voluntary and involuntary risktaking residents and property owners in natural hazard zones. Similarly the largest fraction of the costs of such federally-provided area protection facilities as dams, seawalls, dikes, and channel improvements is being shifted to the general body of taxpayers rather than being imposed on those who are the primary recipients of the benefits derived from these facilities.

By June 1975, the multi-decade cost of flood control-projects completed under the supervision of the U.S. Corps of Engineers totaled $10.2 billion (in non-constant dollars). The overwhelming fraction of these costs were incurred between 1936 and 1975. Direct federal expenditures for disaster assistance totaled more than $4 billion between 1953 and 1973. Currently, from $158 to $173 million per year are being expended from tax revenues to subsidize flood insurance programs and additional substantial sums are being expended for the annual operation and maintenance of existing area flood protection facilities, for technology development and transfer operations, and for administration of other hazard-related programs. The available evidence suggests that annual expenditures for this mix of purposes are increasing and will continue to increase for several decades to come.

6. Financial Institutions and Mortgage Guarantors

Whether their seats of business activity are inside or outside hazard zones, financial institutions and mortgage guarantors clearly have a stake in the structural integrity and life span of buildings located within hazard zones and therefore have an interest in the costs and benefits associated with mitigations intended to protect and extend structural life.

B. Mitigation-Involved Parties

Included in this class are those stakeholders who must either make the basic public decisions to mitigate the effects of natural hazard exposures, or who must engage in the direct extension of mitigation-producing services.

1. State and Federal Policy-Makers

As depicted in Figure 1, perceived public problems are the basic phenomena which motivate policy-makers to take action. However, not all public problems are acted upon, or can be acted upon. Those which receive policy-maker attention are those which have produced disatisfaction among significant constituencies and which have led to the generation of demands or claims upon the policy-making system.

Whether dealing with natural hazards or other socially significant phenomena, policy-makers prefer to adopt "distributive" rather than "regulatory" policies [Mayhew, 1974; Ripley and Franklin, 1976; Vogler, 1977; Mann, 1975] and exhibit a propensity to evaluate proposals in terms of what they will do for their own constituencies and their own chances for re-election [Mayhew, 1974]. Proposals advanced by large constituencies command more attention than those advanced by small or virtually non-existent ones [Schattschneider, 1960; Greenwald, 1977; Dexter, 1969]. With respect to natural hazards and other potential problems, advocates of public policies must, therefore, consider the need for a constituency to be associated with their proposals [Olson, 1971; Jones, 1977]. Further, of course, it is clear that members of a potential risk-exposed constituency must perceive the risk associated with a hazard exposure if they are, subsequently, to be willing to organize so as to support risk-reduction proposals [Cobb and Elder, 1972; Schattschneider, 1960], and to bring them to the attention of appropriate policy-makers.

Finally, in respect to problems involving the public health and safety, policy-makers seem to respond more vigorously and massively to infrequently-occurring but very visible "high consequence" events than to less visible but more frequently-occurring "low consequence" events. Thus, federal safety research and development appropriations per death in total commercial air accidents are orders of magnitude greater than expenditures per death produced by motor vehicle accidents. In terms of total life loss per year, the latter is far more important than the former. However, fatal motor vehicle accidents are every-day events and involve few deaths per event. In contrast, the former occur only rarely, but when they occur they are highly publicized and involve many deaths.

This perspective of death-producing phenomena is not unique to policy-makers. There is an apparently pervasive social tendency to overstate the impacts of hazards that produce deaths (rather than just injuries), and that take multiple rather than single lives. Moreover, there is a companion propensity to underestimate the risks from common, undramatic hazards that claim one person at a time [Slovic, Fischhoff, and Lichtenstein, 1976].

2. Local Policy-Makers

The local policy-maker rides the horns of a special dilemma in respect to hazards management. On the one hand, the ethic of representational government decrees that he or she faithfully represent the views of the existing electorate, and on the other hand the interests of countless other parties may be adversely impacted by the prevailing views of that electorate. Non-voting second-home owners, the interests of potential future residents, the interests of outside investors, and the interests of vacationing and transient populations may be affected by local policy-making decisions; but the local policy-maker is held accountable only to the resident electorate. Similarly, the policy-maker in small jurisdictions usually is not a full-time or technically-trained individual. He or she is beset by competing demands from adjoining and higher jurisdictions of government, from the variety of constituents to which he or she is accountable, and is asked to make decisions involving complex questions of fact and value which cut across numerous technical and scientific fields. Limited by time and technical capacity, these individuals are greatly dependent on the findings, opinions, and recommendations of their local states and of highly regarded "others" in their environments.

In a recent study, researchers found that local policy-makers and opinion leaders in hazard-prone areas do not view natural hazards as being a high priority policy subject. To the extent that these individuals perceive a need for mitigating the effects of natural hazard exposures, they prefer "distributive" to "regulatory" policies [Wright, Wright, and Rossi, 1978].

3. Local and State Planners and Building Officials

Over the past decade several responsible authors, study groups, and commissions have suggested that local planners and building officials are less well trained and less informed on important matters than the real demands of their jobs require. [Municipal Manpower Commission, 1965; National Commission on Urban Problems, 1968; Field and Rivkin, 1975; Steinbrugge, et. al., 1978]. Wedded to their local turfs and to the interests of their local communities, this group of underpaid but extraordinarily important public officials is beset by numerous competing demands from adjoining and higher jurisdictions of government. Many of these demands are more procedural

than substantive or technical; and this situation has all too frequently created adherence to procedural detail rather than to the substantive requirements of community problems and to a fully professional approach to the demands of their offices. Limited by time, interest, constituency requirements, past training, and by their current willingness and capacity to acquire knowledge concerning new subjects, a major burden of future natural hazard management activities will fall upon this group. Far too little is known about the characteristics and developmental needs of these stakeholders, but it seems safe to suggest that their training and staff development needs are large and, as yet, essentially unsatisfied.

4. Code Writers and Criteria Developers

Numerous groups engage in the development of model building codes, suggested planning and zoning ordinances, and other documents which are widely utilized in official policy-making efforts at local, state, and federal levels. In this effort the assumptions, perspectives, and motivations of many individuals play important roles in the quality, efficacy, and cost-feasibility of the outcomes. Functioning in a world of imperfect knowledge, much emphasis is placed by such groups on past experience and informed guesswork. To the members of this group the need to empirically verify the assumptions upon which such documents reside may be of far less importance than "getting the job done."

5. Insurers and Reinsurers

One potentially effective means for avoiding the severe personal, familial, and community distress produced by large hazard-induced losses involves schemes for spreading such losses among the relevant total group of local, regional, or national risktakers. However, tax law restrictions on maintenance of liquid reserves, problems associated with the non-liquidity of investments, and the sheer magnitude of the episodic losses which may be sustained during major hazard-induced catastrophes constitute severe impediments to the willingness and capacity of insurers and reinsurers to engage in the design and delivery of needed risk-distributing systems for occupants and investors in high-hazard areas.

C. Mitigation-Constraining Parties

Members of this final set of stakeholders are distinguishable, not because of the losses they sustain as a result of exposure to natural hazards, but because of their potentially important roles in generating external constraints on public policy-makers and administrators involved in natural hazards management activities.

1. Land Speculators and Developers

Because of their natural scenic, climatologic, or recreational amenities, many hazard-prone land areas are attractive sites for future development. Accordingly, the interests of land speculators, other land owners, subdividers, and builders are affected both by any future imposition of governmental restrictions governing the use of the land, the disclosure of information concerning its hazard-proneness to prospective purchasers, and by future governmental investment policies concerning the provision of hazard-related area protection works.

Major opposition to hazard zone land planning and hazard management schemes may be expected from such parties. Moreover, to the extent that the interests of land speculators coincide with those of businessmen and other economically motivated parties whose future economic well-being may be tied to rates of development within hazard-prone areas, it can be expected that highly organized and vocal opposition will emanate from such quarters in respect to proposed hazard zone avoidance and risk reduction schemes.

2. Opponents of Governmental Regulation

In the United States, recent years have witnessed the development of widespread theoretical and political opposition to numerous types of governmental regulatory activities, including many that were once popularly supported and clearly addressed to public needs. Solid questions have been raised concerning the public benefit/cost ratios associated with many existing regulatory programs, and have fueled developing citizen interest in less overt forms of government intrusion into market operations. Both "conservatives" and "liberals" are increasingly discussing "informal personal choice" and decentralized forms of decision-making as possible alternatives

to traditional governmental regulatory programs and policies.

Individuals who are committed to their views as a matter of principle, rather than personal self-interest, comprise the membership of this stakeholder group. They may be expected to demand that governmental approaches to natural hazard exposure losses consider the full range of loss-reducing alternatives with particular emphasis on those that stop short of comprehensive, nation-wide, centrally imposed regulatory schemes.

3. Advocates of Governmental Economy

Prompted by California's adoption of Proposition Thirteen (the local tax rate limitation amendment to the California constitution), a national campaign to reduce governmental expenditures and public tax burdens is now underway. Supported by a broad-base of public and policy-maker opinion, the campaign is forcing governmental entities and jurisdictions to re-evaluate once unquestioned programs and expenditures, to re-order old priorities, and to divert tax monies to expenditure targets which yield the greatest publicly-desired payoffs per unit of investment.

In the future, members of this stakeholder group can probably be expected to question or oppose government expenditure policies which have the effect of transferring the cost of area protection facilities and/or the losses experienced by some types of natural hazard risktakers to non-risktaking or non-benefiting parties.

4. Supporters of Natural Hazard Management Programs

No clearly identifiable constituency has yet to emerge on the national scene to argue on behalf of comprehensively-oriented natural hazards management policies and programs. By and large, discussions of this topic have thus far been dominated by researchers committed to this subject as a field of scientific inquiry, by professionals involved in existing aspects of the field, by environmentalists, and by groups whose interests in the subject are of a short-term and "pork-barreling" nature. The development of such a constituency may well be a necessary condition to any future comprehensive revision of natural hazard management policies and programs.

VI

PUBLIC PROBLEMS ANALYSIS: THE CANDIDATE PUBLIC PROBLEMS

Introduction

The states of affairs that are referred to as "problems" are as much a product of human values and of human perceptions as they are of the empirical reality to which they are presumed to relate. Because these states of affairs require acts of human valuing, they must be viewed by an analyst as being potentially different from the states of affairs that may be identified objectively as "impacts," "consequences," or "effects." Objectively, an analyst may state that the effect of activity "A" will be to increase the cost of product "B" by an amount "C" to a consumer "D" and therefore consume "E" percent of "D's" family income. Whether that increased cost produces a "problem" for "D" is a question that hinges on the values and reality perceptions of "D" himself, or some other value-holding party who presumes to fix the values by which the affairs and life situations of others are to be judged.

Further difficulties are faced when one tries to distinguish between the class of events that are viewed as "problems" and those that are viewed as "public problems." In our society, not all problems are viewed as being public problems, nor are all public problems necessarily placed on the agenda for public policy action. Some are simply acknowledged as being extant but as being either too trivial or too politically infeasible to resolve to warrant the concern of the community and/or government.

Accordingly, considerable peril is faced by the analyst who presumes to state what "public problems" are associated with a particular situation or set of situations under examination. For this reason, the following list is to be viewed as consisting of candidate states of affairs each of which may be viewed by some significant stakeholder group as constituting a public problem.

The list of candidate public problems has been divided into two major sections conforming to the study team's assessment as to whether or not the focal states described may be classed essentially as being "intrinsic" or "instrumental" problems. Intrinsic states or problems are those that are unwanted, not in and of themselves, but because they lead to, or are perceived to lead to, still other states of affairs that are intrinsically unwanted.

Intrinsic Candidate Public Problems

Ten states of affairs have been identified by the project team as comprising the major candidate "intrinsic" public problems associated with natural hazard exposures or with efforts to mitigate such exposures. The first seven of these problems are intended to represent the publicly unwanted situations that comprise the essential justification for natural hazard management policy-making, particularly at the national level. The remaining three problem statements are intended to represent the primary constraints to be met by decision-making aimed at the resolution of the first seven problems. Considered as an interlocked whole, the suspected existence of these ten problems explains why the situations described as "instrumental problems" are viewed as "unwanted" situations or states of affairs.

The relationship of each "intrinsic" public problem to the several stakeholder groups identified above is depicted in Figure 12. In each case, the matching of a stakeholder group with a problem through the note "P" is meant to suggest that the identified group is the problem-impacted party. The note "B+" is meant to suggest that the identified group is a "beneficiary" or "affected" party whose interests may positively be served by problem-solving activities, while a "B-" indicates that group interests will be negatively served by such problem-solving activities.

The failure to describe mitigation-induced economic injury to some business groups as constituting a public problem is borne, not out of any bias of the project team, but out of its interpretation of what constitutes the system-governing and problem-defining value propositions of our social, governmental, and economic systems.

STAKEHOLDERS	CANDIDATE INTRINSIC PROBLEMS									
	1. INDIVIDUALS, FAMILIES AND BUSINESSES AT RISK	2. WHOLE COMMUNITIES AT RISK	3. VISITORS INCUR INVOLUNTARY RISK	4. LOSSES MAY EXCEED MITIGATION COSTS	5. REDUCED PROBABILITY OF MORTGAGE PAYOFF	6. EXPECTED INCREASE IN MAGNITUDE OF PROBLEMS	7. COSTS TRANSFERRED TO NON-RISKTAKING TAXPAYERS	8. MITIGATION POLICIES INCREASE PROPERTY COSTS	9. POLICIES CONFLICT WITH PERSONAL OR COMMUNITY VALUES	10. CONFLICT WITH OTHER NATIONAL PRIORITIES
PRESENT RESIDENTS	P B+	P B+	B-	P B+		P B+	P B+	P B+	P B+	P B+
POTENTIAL FUTURE RESIDENTS	B+	B+	B+	B+	B+	P B+	B-	P B+	B+	B+
VISITORS OR WORKERS	P B+		P B+			P B+				P B+
OWNERS AND USERS OF SECOND HOMES	P B+	P B+	P B+		P B+	B-	P B+	P B+	P B+	P B+
NON-RISKTAKING BEARERS OF HAZARD COSTS	B+		B+	B-	B+	B+	B+	B+	B+	B+
FINANCIAL INSTITUTIONS AND MORTGAGE GUARANTORS	B+	B+	P B+	P B+	P B+	P B+	B-	B+	B-	
STATE AND FEDERAL POLICY MAKERS										
LOCAL POLICY MAKERS		P B+				P B+	B?		B-	B+
CODE WRITERS AND CRITERIA DEVELOPERS		B+		B+		B+		B+	B-	
INSURERS AND REINSURERS	B+		B+	P B+	P B+	P B+	B-	B+	B-	
LAND SPECULATORS AND DEVELOPERS	P B+	B+	B-	P B+	P B-	P B+	P B-	P B+	P B+	P B+
OPPONENTS OF GOVERNMENT REGULATION							P			
ADVOCATES OF GOVERNMENT ECONOMY										
SUPPORTERS OF NATURAL HAZARD MANAGEMENT PROGRAMS										

KEY:

P = Problem-Impacted Party
B+ = Beneficiary Party
B- = Interests will be negatively served

Figure 12 Relationship of Candidate Intrinsic Problems to 14 Stakeholders

1. Large numbers of individuals, families, and businesses are now at risk of experiencing significant economic and other losses as a result of their exposure to natural hazards in their home communities.

In 1970, annual expected total dollar losses arising from the exposure of buildings and their contents to nine natural hazards totalled approximately $8.1 billion. These same exposures also were expected to yield 979 deaths per year, a loss of 114,000 housing units, 129,850 person-years of homelessness, and nearly 80,000 person-years of unemployment. Approximately 33% of all building damage losses were sustained by flood-threatened parties who constituted less than 8.0% of the U.S. population. At the scale of whole counties and states, annual expected per capita losses from natural hazard exposures range from nearly $220 for the highest damage rate county to only $16.86 in Vermont. Within the nation's 500 most damage-prone counties (for all natural hazards except riverine flooding), annual expected per capita losses ranged from $21.18 to approximately $220 in 1970. In terms of more finely drawn hazard zones, annual expected losses totalled slightly more than $402 per capita for occupants of riverine flood zones A to C in communities not protected from 50-year floods; $121 per capita per year in the storm surge flood plains of Georgia; $24 per capita per year for the three counties exhibiting the highest average annual number of tornado strikes; $28 per capita per year for occupants in states with the highest annual expected damage rate from earthquakes; approximately the same for individuals in the state exhibiting the highest hurricane wind hazard; and $26 per capita per year for occupants of intra-county areas that are within high expansive soils zones. Occupants of 500-year tsunami inundation plains in 1970 were found to be at risk of experiencing annual expected losses totalling approximately $37 per capita.

In single catastrophic events, such as major earthquakes or hurricanes, residents in the counties experiencing the highest magnitude of the occurrence were found to be at risk of experiencing per capita episodic losses in excess of $16,000.

2. Many whole communities are at risk of experiencing catastrophic losses as a result of hazardous natural events.

In 1972, the Office of Emergency Preparedness reported to the Congress that increasing population density, inadequate evacuation routes, ineffective building codes, and insufficient provision of safe refuges are increasing the probability of a major hurricane catastrophe along the Atlantic and Gulf coasts [Office of Emergency Preparedness, 1972]. The report noted that some states vulnerable to hurricanes do not have statutory authority to order evacuation on the scale and at the time a hurricane advisory might indicate the need for such action; that numerous local communities and large jurisdictions lack adequate knowledge concerning their vulnerability to natural disaster; that both private citizens and local public officials are not aware of the natural disaster hazards existing in the area in which they live, the likelihood of their occurrence, and the measures that property owners can take to avoid or mitigate them; and that comparatively few vulnerable communities have prepared effective plans for dealing with tsunami. In a more recent report by the Working Group on Earthquake Hazards Reduction of the Office of Science and Technology Policy [Steinbrugge, 1978], it was noted that current federal and state earthquake contingency planning is inadequate to produce effective responses to a large magnitude earthquake in or near a heavily populated region; that tsunami flood zones have not been adequately defined and that mitigation practices within tsunami-prone areas are deficient; that inadequate action has been taken to cope with the hazards posed by poorly constructed older structures (generally buildings constructed of unreinforced masonry) in cities at high risk of seismic disturbances; and that existing information about earthquake hazards is generally neither sufficiently detailed nor in a form that can be used in land use planning and in implementing hazards avoidance or mitigation plans.

Although recent studies have shown that few long-term economic impacts have been incurred by communities as a result of their exposure to hazardous natural events, it is also clear that the recovery capacity of these communities has been greatly influenced by the infusion of disaster relief funds from outside areas and jurisdictions. Also, natural hazard exposures of the high magnitudes that can be expected to occur in this country in one or more major

metropolitan areas have not yet been experienced during the current century.

3. Involuntary risks are being incurred by significant numbers of migrants, workers, customers, and tourists who enter unknowingly into natural hazard zones.

When the general attitude of the public that government will protect them is combined with the high level of residential mobility, intercommunity migration, and away-from-home shopping, working, and vacationing habits, and when these factors are further associated with the fact that neither hazard zone occupants nor outsiders possess much knowledge concerning the risks associated with specific sites, then it seems clear that a substantial number of non-hazard zone residents are being exposed unknowingly and, therefore, involuntarily to risk-taking within natural hazard zones. At present, those parties who sell, offer to sell, or participate in the transfer of property from one owner to another are not generally required to disclose to the possible new owner information concerning the hazard-proneness of the property.

4. Annual economic losses in excess of the probable annual amortized costs of mitigations are being experienced by parties located within many natural hazard zones.

In approximately 230 U.S. counties, the application of building-strengthening strategies is capable of reducing annual expected natural hazard losses by amounts greater than the annual amortized costs of the mitigation. In numerous riverine flood zones, coastal storm surge areas, and other hazard zones, combinations of building-strengthening, area protection, or avoidance strategies also may reduce annual expected natural hazard losses by amounts greater than the annual amortized costs of the mitigation.

5. The probability of payoff of some loans and mortgages to private financial institutions, public entities, and mortgage guarantors is being reduced by continuing imprudent investments in high hazard zones.

Although the quantitative magnitude of this problem cannot readily be identified,

the data generated by this study suggest that the situation described in this problem statement is both real and probably expanding.

6. Unless appropriate corrective measures are taken, the above problems will increase in magnitude between 1980 and 2000.

Current patterns of interstate, intercommunity, and intracommunity residential change and capital investment are increasing the size of the nation's population at risk of exposure to natural hazards. The projected increase in total natural hazard economic losses between 1970 and 2000 is in excess of the annual expected loss in 1970.

7. A significant fraction of the costs of voluntary and involuntary natural hazard risk-taking is being transferred to the general body of non-risk-taking taxpayers.

Because of the numerous aids and subsidies contained in current federal natural hazard mitigation and relief legislation, a significant and growing fraction of the national annual cost of natural hazard exposures is being transferred to parties who do not reside within the hazard zones in which these losses are incurred. Although the 1936 Flood Control Act provided for cost sharing by state and local governments in federally initiated flood control projects, that provision was dropped shortly after the enactment of the statute, and the bulk of flood control costs subsequently have been borne by the general body of taxpayers. Similarly, numerous occurrences now qualify for disaster designation under the terms of the Federal Disaster Relief Act, and parties experiencing losses during such events are entitled to a wide variety of benefits from the federal government, including forgivable loans, interest-free loans, direct recovery services, and federally financed reconstruction of community lifelines and other infrastructure.

The availability of these benefits has sometimes been cited as constituting an incentive for individuals to enter into high hazard zones and as a deterrent to local and personal initiation of more economical hazard avoidance, hazard mitigation, or hazard adjustment activities.

8. Purchasers and users of property face an escalation in the initial and annual amortized cost of such property as a result of governmentally required building-strengthening and other hazard-mitigating requirements.

This study has made clear that overzealous, across-the-board strengthening of building codes may well increase by a substantial amount the net annual burden associated with natural hazard exposures (see Table 9). Other studies performed within the past decade or so also have suggested that building code requirements in many areas may exceed the objective needs of public health, safety, and building life, and be imposing unnecessary cost burdens on a housing-hungry population [National Commission on Urban Problems, 1968; Field and Rivkin, 1975]. More recently, the Working Group on Earthquake Hazards Reduction has noted that current seismic codes do not adequately balance the risks of quake-inducing damage against the cost of applying mitigations, and further observed that some building codes do not reflect the current state of the art in respect to earthquake-resistant design.

A more careful study of the contents, costs, and benefits of current building code requirements seems clearly to be warranted.

9. The ability of individuals and whole communities to engage in courses of personal and community action compatible with their own values may be threatened by action-forcing and regulatory policies adopted by state and federal governmental entitles.

From a national, regional, or state perspective, the data presented in this and other similar reports does not make it easy for any compassionate or rational analyst/observer to determine "what is right." Indeed, the data suggests that there may be many "rights," many possible courses of action that are consistent with the objective realities of the natural hazard situation and the prevailing values of specific communities and of the nation as a whole. Decision-making by higher units of government that require uniform or near-uniform application of limited perspectives and value choices across the face of the country therefore run the risk of overlooking "acceptable alternatives" that might be applied in specific locales by men and women guided both by intelligence and goodwill.

A leading nineteenth century political and legal philisopher once observed that the "public interest requires that we do today what men of intelligence and goodwill would wish--five or ten years hence--had been done." From this perspective, natural hazard situations are so complex, the values contained within them so numerous, and the possibilities for action so various, that there may be many "rights," and many ways to fulfill the "public interest" as that interest is perceived in many specific places and in varying specific times.

10. An over-reaction to natural hazard losses may impair our national capacity to realize otherwise achievable improvements in human longevity and life quality.

Like other nations, the United States is plagued by a long list of public problems and by an expanding agenda of public wants and goals. Given limited knowledge concerning the costs and benefits associated with the expanding variety of policies and actions that may be taken in respect to these problems and goals, beset by competing claims from politically organized groups, and further limited by objective evidence and perceptions concerning the interrelationships between the whole, the major actors within the American public policy system are in continuing danger of misallocating limited available public resources.

As compared with other problem situations, it is easy for researchers, activists, regulators, and technical advisers to overstate the importance of the phenomena that are the focal points of their professional lives. So it is in respect to natural hazard exposures.

It seems clear that additional study and information synthesis should take place to identify and priority-rank the numerous natural and man-made hazard zones within which both resident and transient populations are at risk of experiencing consequences of various magnitudes, frequencies, and importance to themselves and to the nation as a whole. If our system-spanning national objectives are to achieve the greatest extensions in human longevity, the maximum improvements in life quality, and the largest gains in the economic

CANDIDATE INTRINSIC PROBLEMS	CANDIDATE INSTRUMENTAL PROBLEMS												
	1. INADEQUATE PROGRESS IN HAZARD ZONE MAPPING	2. INADEQUATE DATA FOR DEVELOPING MITIGATION CRITERIA	3. INADEQUATE DATA TO ESTABLISH COST-LOSS REDUCTION RATIOS FOR MITIGATION	4. INADEQUATE INFORMATION TO SUPPORT MODEL BUILDING CODE REQUIREMENTS	5. LOCAL BUILDING CODES OF UNCERTAIN QUALITY CAN BE INCOMPATIBLE WITH NATURAL HAZARDS MANAGEMENT	6. LIMITED EFFECTIVE LOCAL PLANNING AND IMPLEMENTATION	7. LOW LEVEL OF LOCAL NATURAL HAZARD PERCEPTIONS	8. WEAK CONSTITUENCY FOR NATURAL HAZARD POLICY	9. POLICY FAVORS FINANCIAL ASSISTANCE AND AREA PROTECTION WORKS	10. INADEQUATE COORDINATION OF FEDERAL NATURAL HAZARD PROGRAMS	11. LIMITED OPPORTUNITY TO PURCHASE HAZARD INSURANCE	12. LOW PUBLIC INTEREST IN NATURAL HAZARD INSURANCE WHEN AVAILABLE	13. FEDERAL RESEARCH EXPENDITURES NOT MATCHED WITH ANNUAL EXPECTED LOSSES
1. INDIVIDUALS, FAMILIES AND BUSINESSES AT RISK	++	++	++	++	++	++	++	++	++	++	++	++	++
2. WHOLE COMMUNITIES AT RISK	++	++	++	++	++	++	++	++	++		++	++	++
3. VISITORS INCUR INVOLUNTARY RISK	++	++	++	+	+	+	++	+	+	+	0	0	+
4. LOSSES MAY EXCEED MITIGATION COSTS	+	++	++	++	++	++	+	++	+	++	++	++	++
5. REDUCED PROBABILITY OF MORTGAGE PAYOFF	+	++	++	++	++	++	+	+	+/-	+	++	++	+
6. EXPECTED INCREASE IN MAGNITUDE OF PROBLEMS	++	++	++	++	++	++	++	++	++	++	++	++	++
7. COSTS TRANSFERRED TO NON-RISKTAKING TAXPAYERS	0	0	+	+	++	+	0	-	++	++	++	++	0
8. POLICIES INCREASE PROPERTY COST	+	+	+	++	++	+	0	0	-	+	++	++	+
9. POLICIES CONFLICT WITH PERSONAL OR COMMUNITY VALUES	++	++	++	+	+	+	++	+	+	++	0	0	+
10. CONFLICT WITH OTHER NATIONAL PRIORITIES	+	+	+	++	++	+	++	0	+	+	0	0	+

KEY: Effect of resolution of instrumental problems on the resolution of intrinsic problems

++ Very Supportive 0 No Effect

+ Supportive - Detrimental

Figure 13. Relationship between Intrinsic and Instrumental Candidate Public Problems

efficiency of our society per million dollars of available public resources expended, then the subject of human hazard exposures would profit from inquiry conducted within larger contexts.

To the extent that the "Proposition 13 syndrome" is one that may beset most regions of the country and all levels of government, then it may well be that public expenditures at all levels will be constrained more severely in the future than they have in the past and that the need for such comprehensive problem assessment and policy planning will be even larger than intimated here.

Instrumental Candidate Public Problems

Situations or states of affairs whose existence contributes to the occurrence of, or impedes the mitigation of, "intrinsic" problem states are here referred to as "instrumental" public problems. In these terms, their solution is justified only in terms of the extent to which they contribute to the solution of "intrinsic" problems. The assumed relationship between the candidate "instrumental" problems identified below and the "intrinsic" problems identified above are depicted in Figure 13.

1. Hazard Zone Identification, Mapping, and Classification: The past rate of progress in identifying, mapping, and classifying natural hazard zones has been inadequate; too few zones have been so mapped; and inappropriate or incomplete information has been provided map users concerning the frequency and magnitude of hazard occurrences within such zones.

Timely, effective, and rational natural hazard management activities are dependent on the availability, accessibility, quality, understandability, and comprehensiveness of information concerning the metes and bounds of local natural hazard zones and their component sections, the frequency and magnitude of hazardous occurrences expected within the various sections of these zones, and concerning the hazard-relevant geo-physical characteristics (such as soil type) of elements of the several sections of the zone.

Thus, the Working Group on Earthquake Hazards Reduction has observed that current seismic risk maps are in conflict with each other; do not present alternative levels of risk; do not adequately incorporate "engineering considerations;" and are not available for a sufficient number of areas within the nation. The group noted that existing information about earthquake hazards is generally neither sufficiently detailed nor in a form that can be used either in land use planning or in actions intended to implement plans for avoiding hazards and mitigating damages. Agreeing with the Office of Emergency Preparedness, the group noted that tsunami flood zones have not been adequately defined. Virtually all those who have examined natural hazard occurrences within the United States have noted the need for hazard zone and risk mapping and have commented on the general lack of such information. This information deficiency may well lie behind the generally unsatisfactory level of public and policy-maker understanding of natural hazards within local communities and larger jurisdictions. In respect to the mapping of riverine flood plains, the General Accounting Office has noted the formidable mapping problems associated with meeting the statutory objectives of the Federal Flood Insurance program [Comptroller General of the United States, 1976].

Cost requirements associated with high-quality and timely hazard zone mapping activities, together with the human and technical resource requirements associated with this function, suggest that central federal priority-setting should take place in respect to this matter.

Whatever the final priorities may be, it seems appropriate to suggest that they should be fixed in consonance with the annual expected losses associated with exposures within the various types of hazard zones, the sizes of the populations currently at risk, and with the growth in losses and population exposures expected between now and the year 2000. Moreover, it may be well to reconsider the appropriateness of the past federal role in this process and to place greater emphasis on federal establishment of criteria and standards to be employed in such mapping and zone-classifying activities, as contrasted to direct federal conduct or financing of these operations. Expanded roles for state and regional planning agencies are not difficult to

conceive, nor are requirements for public hearings and technical review of map outputs prior to their official publication and endorsement.

2. Inadequate methods and data now are available for use in operations targeted on the development of empirically defensible mitigation criteria.

As utilized in this problem statement, the term criteria is meant to refer to a predictive or descriptive statement that describes the level of loss or damage reduction which may be expected at any given level of intensity or frequency of hazard occurrence or that may be derived from use of any specified mitigation. For many hazards, such as expansive soils, the current data base is woefully inadequate. For almost all hazards, some additional data are required.

3. Inadequate procedures and pools of data have been provided to assist technical and regulatory bodies in their establishment of empirically defensible statements concerning the cost/loss reduction ratios associated with the use of specific mitigations in specific types and sections of natural hazard zones.

4. In respect to natural hazard mitigations, significant differences can be noted in the content of "model building codes;" and too little empirically defensible information is available to support the numerous judgments that have entered into the specification of "model code" requirements.

5. Local building codes are generally of uncertain quality, too infrequently reviewed and revised, and sometimes based on motivations and purposes that may not clearly be in the public interest nor compatible with the ends of rational natural hazards management.

The Working Group on Earthquake Hazards Reduction noted that some building codes do not reflect the current state of the art in respect to earthquake-resistant design and further observed that some of the model building codes may not be completely adaptable to all areas of the United States with their different degrees of seismic risk. The group further observed that these codes do not adequately balance the risks of quake-induced damage against the

costs of mitigation. They further noted that inadequate action has been taken to implement building code or other regulatory provisions intended to deal with the hazards posed by older, non-earthquake-resistant structures. Similarly, the Office of Emergency Preparedness reported in 1972 that state and local legislation has not kept pace with the growing problems of natural disasters and that "ineffective building codes" in communities along the Atlantic and Gulf coasts are exacerbating the probability of a major hurricane catastrophe in that area. The National Commission on Urban Problems reported in 1968 that "building code jurisdictions are thousands of little kingdoms, each having its own way: what goes in one town won't go in another--and for no good reason." The Commission concurred in the view that "the provisions in codes are antiquated and outdated and that the procedures for modernizing and amending them are slow, laborious, and lacking in objective standards." The Commission was so concerned with the quality of local building codes that their recommendations called, in part, for "minimum standards below which no community might fall and maximum limits in order to prevent restrictive practices" [National Commission on Urban Problems, 1968].

6. Local planning and building regulation departments and professional staffs exhibit limited capacity to engage in effective natural hazard policy planning and implementing activities.

The staffs of building departments at the local level generally are drawn from local construction trades, are paid extraordinarily low salaries, and typically lack the time and training to engage in the technically demanding function of reviewing, revising, and developing hazard-related building codes. Similarly, land use and regional planners typically have not received academic training on subjects related to natural hazards; and even professionally-trained architects and engineers frequently exhibit the same incapacity.

Although quantitative defense of this view is rarely offered, most groups that have examined this subject seem to be in agreement with the assumptions implicit in this problem statement. If true, the statement suggests the need for much technical assistance and training support to these staffs by state and federal entities. At a minimum, there appears to be a need for a well-executed and unbiased study of this situation.

7. There is a comparatively low level of public and policy-maker perception of the natural hazards that exist within their communities and of the consequences associated with continuing exposure to those hazards.

8. There is no apparent "political constituency" that has emerged to argue on behalf of comprehensive and rationally conceived natural hazard management policies at any level of government; but limited constituencies have developed that argue against imposition of natural hazard management action-forcing policies upon local governments by state and federal units of government.

9. The major public and policy-maker demands in respect to natural hazard management policies are tilted in favor of: (a) financial and other forms of assistance to disaster-impacted parties; and (b) area protection works funded by the nation as a whole.

10. Inadequate coordination has been provided to hazard management programs conducted by the federal government.

Several reports of recent vintage have noted the absence of central leadership and coordination of natural hazard management programs within the federal structure; the lack of coordination of flood plain-directed programs; and of programs intended to develop public and policy-maker understanding of the extent of the natural hazard problem and of appropriate natural hazard mitigations. According to the Working Group on Earthquake Hazards Reduction, there has been virtually no integrated coordination of federal land use planning and development programs with those more pointedly related to natural hazard exposures. Similarly, there seems to have been little integration of employment programs for the chronically or occasionally unemployed (such as CETA) with the aims of natural hazard management activities (such as removal of structures from high hazard zones).

The recent presidential announcement that accompanied the proposed reorganization of federal disaster management functions contained an acknowledgment of the need for a more comprehensively and centrally oriented organizational structure to cope with the mix of functions related to the initiation of hazard mitigation programs and to the provision of relief and recovery services

after the occurrence of hazard-induced disasters.

11. In general, populations at risk of exposure to natural hazards do not now have the opportunity to purchase insurance of appropriate coverage at desirable rates so as to spread the risk of their exposure-induced losses among the relevant population of risktakers.

Although federally subsidized flood insurance is now available and commercial insurance against selected other natural hazards is now offered by some companies in some parts of the United States, it is not generally possible at present for property owners to purchase all-purpose natural hazard insurance coverage and, therefore, to take advantage of this means for avoiding catastrophic losses arising from natural hazard exposures. The absence of this opportunity probably directs undue attention to other methods for mitigating potentially catastrophic natural hazard losses, including those related to provision of area protection facilities and to use of building-strengthening technologies. From a cost-benefit point of view, insurance coverage may well be a better solution to some aspects of the loss problems associated with natural hazard exposures than other approaches. At the very least, insurance can be an important partner in a comprehensively oriented loss-reducing strategy.

A variety of factors may be influencing the lack of these insurance opportunities, including some having to do with tax code constraints on maintenance of liquid reserves; the difficulties and risks faced by insurers and re-insurers in meeting the "unusual" financial requirements associated with possible catastrophic occurrences; and other similar factors. There appears to be a substantial need for a thorough, empirically sound study of this entire subject.

12. Even where natural hazards insurance is available, public interest in the purchase of such insurance has not been particularly high.

13. Federal expenditures for hazard-related research and technology development projects have not exhibited an appropriate match with the annual expected losses associated with exposure to various hazards nor with the size of the populations at risk of exposure to such hazards.

However laudable, natural hazards research and technology development efforts within the federal structure have tended to respond to the "natural disaster of the moment" rather than to the total mix of potential natural hazard exposure problems. However well-advised the research expenditures authorized under the Earthquake Hazards Reduction Act, it appears that far more attention is being given to this hazard than to other types of hazard exposures which are of equal or greater national importance. Thus, apparently large annual losses are being sustained as the result of property exposures to expansive soils, but comparatively little is known about this phenomenon. Similarly, too little research and technology development is being directed toward means of coping with coastal flooding, landslide, and wind hazards. The whole subject of cost-benefit relationships in building code standards has for too long been ignored; and the substantial technical assistance and training requirements of state and local planning, hazard management, and building code agencies and personnel have gone too long unattended. The reports by Steinbrugge (1978); the National Commission on Urban Problems (1968); and White and Haas (1975) provide a context for future deliberations on this subject.

However, none of the reports examined by the study team have clearly, explicitly, and rationally offered defensible criteria through which the desirability, feasibility, and priority of alternative research, technology development, and technology transfer opportunities could be judged. Certainly, such factors as the scope of the problem addressed, the need for the information, the loss-reducing potential of new knowledge, and the state of the current knowledge base are factors that should be utilized to judge such matters. Moreover, there has been too little effort made by federal funding agencies to comprehensively assess research and other needs related to human and property exposures in all types of hazard zones, including those of natural and man-made origin. All too little now is known about the comparative risks incurred by individuals and property exposed to conditions in a variety of natural and man-induced hazard zones, and we, therefore, lack an appropriate basis for policy-making in respect to this subject.

VII

DESCRIPTIVE PUBLIC POLICY ANALYSIS: PAST AND PRESENT PUBLIC APPROACHES TO THE MANAGEMENT OF NATURAL HAZARDS

Types of Hazard-Related Public Policies

Substantial annual investments are being made each year by federal, state, and local governments to deal with natural hazards. These investments are aimed at a range of objectives, including protection of communities from hazard occurrences, forcing the use of loss-reducing technologies by builders and building owners, reducing and spreading the losses sustained by individuals exposed to hazards, identifying and promoting the avoidance of high hazard areas, warning exposed persons of impending hazards, and advancing human understanding concerning hazard occurrences and possible mitigations. These objectives are the focus of a mix of public policies which may be grouped into several major classes:

1. Action-forcing policies: those adopted by higher-level jurisdictions and which are intended to force loss-reducing activities by various units and jurisdictions of government.

2. Attention-focusing policies: those intended to stimulate citizen, group, and governmental interest in losses produced by natural hazards and to promote voluntary state, local, and private action to reduce such losses.

3. Disaster recovery policies: those intended to assist personal, familial, neighborhood, community and state recovery from the damages sustained as a result of exposure to a natural hazard.

4. Technology development policies: those focused on development of new knowledge concerning the subject and on the information and technology necessary to support the making and implementation of hazard mitigating policies.

5. Technology transfer policies: those which are focused on transfer of knowledge to consumers, governments and others; and on the development

of user capacity to make effective use of that knowledge, both in the long term (as in hazard analysis programs) and in the short term (disaster warnings).

6. Regulatory policies: those which involve regulating the decisions and behaviors of private parties and other governmental entities to bring about the reduction of losses associated with exposure to natural hazards. Such policies may involve avoidance, building strengthening, site preparation and other methods.

7. Investment and cost allocation policies: policies concerned with the acquisition and allocation of resources necessary to sustain the activities described above and below. Such policies determine how much will be spent, when, for what purpose, where, and at whose expense.

8. System management policies: intended to fix responsibilities, to specify the means to be employed, and to define the restrictions to be met by hazard mitigation policies and programs.

9. System optimization policies: intended to assure that other policies in the set are compatible with system goals, effective, internally consistent with each other, and in consonance with other policies.

10. Direct action policies: authorizing direct governmental action to implement a policy, such as physical construction or removal of structures (buildings, levees, dams).

This taxonomy of public policies was used to guide our analysis of current federal, state, and local legislation and was constructed on the assumption that complex problems might well require policy actions across the range of posited policy types. The taxonomy differs from the simpler classic model advanced by Lowi and others which holds that there are four broad types of public policies: allocative or distributive; regulatory; structural; and redistributive [Lowi, 1964; Salisbury, 1968; Anderson, 1975; Jones, 1977].

Distributive policies are those which confer benefits or services, which determine what type of service is to be provided to whom, where, and when. Nineteenth century land distribution policies of the federal government, as well as contemporary river and harbor improvements and agricultural and business subsidy programs, are exemplary of this class. On the other hand, redistributive policies are those which calculably are intended to transfer income or wealth from one or more groups of citizens or areas to other groups of citizens or areas. Such policies involve a "conscious attempt by the government to manipulate the allocation of wealth, property, rights, or some other value among broad classes or groups in society." [Ripley and Franklin, 1976]. Structural policies establish organizations and systems for disbursing benefits (for implementing other policies) and provide guidelines for allocating such benefits [Salisbury, 1968].

In contrast to the above, regulatory policies are those that are intended to establish and enforce constraints on citizens and private organizational decision-making and behavior.

Federal Natural Hazard Policies and Programs: An Overview

Federal legislative responses to natural hazards have ranged from authorization for massive investments in area flood control facilities, through the operation of disaster warning systems, to extension of post-disaster assistance to loss-experiencing parties. Major legislative actions specifically addressing natural hazards include:

Flood Control: Since 1936 the federal government has taken the responsibility for constructing major flood control works, and the U.S. Army Corps of Engineers has become the dominant agency operating in this field. In addition, a Dam Inspection Act was passed in Congress in 1972 to initiate safety inspections of private dams as a preventive measure against floods. Also, the Federal Flood Insurance Program has been used to stimulate implementation of floodplain avoidance and flood proofing measures by local units of government.

Disaster Relief: Federal disaster relief legislation was first enacted in 1950, and subsequently in 1966, 1969, 1970, and 1974. Once a disaster has

occurred, a Presidential declaration renders the affected region eligible for special aid for relief and recovery. In addition, the designation as a natural disaster area makes the residents eligible for low-interest loans from the Small Business Administration and the Farmers Home Administration for the repair and rehabilitation of damaged structures.

Earthquakes: The signing into law of the Earthquake Hazards Reduction Act in October 1977 expanded funding for research into the prevention and mitigation of earthquake hazards. Previously, earthquakes had been addressed in general disaster relief legislation, and funds had been appropriated to the National Science Foundation for the study of earthquake prevention engineering ($8 million in fiscal 1974). This Act represents the first broad federal mandate for earthquake mitigation efforts.

Other Subjects: In addition, federal legislation has established a national coastal zone management program, a program of flood insurance, and several mortgage-subsidy programs which empower one or more federal agencies to specify the structural quality of buildings qualifying for a mortgage. Other legislative actions have authorized and funded research, hazard area mapping, and hazard-warning services. Still other legislation has authorized technical training, education, and public information activities which could be targeted, in part, on natural hazard management subjects. In addition, the federal government has moved into the area of establishing structural design requirements for mobile homes. Specifically, in order to obtain the designation of "hurricane resistive", mobile homes must be designed to withstand horizontal wind loads of not less than 25 pounds per square foot (psf) and a net uplift of not less than 15 psf. HUD is authorized to establish more stringent requirements for exposures in the coastal zone. [Federal Register, 1975].

Federal hazards-related legislation of recent vintage includes the acts identified in Figure 14.

TITLE OF LEGISLATION	DATE ENACTED	LAW NUMBER	AGENCY	BUDGETS
1. DISASTER RELIEF ACT OF 1974	1974	PL 93-288	FEDERAL DISASTER ASSISTANCE ADMINISTRATION (FDAA)	$150,000,000 (fiscal 1978)
2. NATIONAL FLOOD INSURANCE ACT	1968	PL 90-448	HUD, FLOOD INSURANCE ADMINISTRATION	$ 91,000,000 (fiscal 1978)
3. FLOOD DISASTER PROTECTION ACT	1973	PL 93-234	HUD, FLOOD INSURANCE ADMINISTRATION	$ 91,000,000 (fiscal 1978)
4. NATIONAL DAM INSPECTION PROGRAM	1972	PL 92-367	ARMY, CORPS OF ENGINEERS	$ 15,000,000
5. EARTHQUAKE HAZARDS REDUCTION ACT	1977	PL 95-124	TO BE DESIGNATED BY THE PRESIDENT	$205,000,000
6. COASTAL ZONE MANAGEMENT ACT	1972	PL 92-583	DEPT. OF COMMERCE, NOAA	$ 27,438,000 (fiscal 1978)
7. MOBILE HOME CONSTRUCTION SAFETY STANDARDS ACT OF 1974	1974	PL 93-383	DEPT. OF HOUSING & URBAN DEVELOPMENT	$ 485,000 (fiscal 1978, est.)

Figure 14. Major National Legislation Related to Natural Hazards (1968-1977)

As shown in Figure15, major natural hazard legislation by the federal government encompasses all ten policy types listed under the taxonomy of mitigation policies. Most frequently represented in federal legislation are technology transfer and attention-focusing policies, and only in the Corps of Engineers flood control activities is the federal government engaged in direct action without operating through other levels of government. The federal government is, however, engaged in direct action with respect to natural hazards as part of numerous other programs as discussed below. The Coastal Zone Management, National Flood Insurance Programs, and the Mobile Home Construction and Safety Standards Act are the only federal activities which involve action forcing policy.

LEGISLATION OR PROGRAM	TYPE OF POLICY									
	ACTION-FORCING	ATTENTION-FOCUSING	DISASTER RECOVERY	TECHNOLOGY DEVELOPMENT	TECHNOLOGY TRANSFER	REGULATORY	INVESTMENT AND COST ALLOCATION	SYSTEM MANAGEMENT	SYSTEM OPTIMIZATION	DIRECT ACTION
NATIONAL FLOOD INSURANCE PROGRAM	●	●	●		●	●	●	●		
NATIONAL DAM INSPECTION PROGRAM		●			●	●	●			
DISASTER RELIEF ACT OF 1974	●	●	●	●	●		●	●		
EARTHQUAKE HAZARDS REDUCTION ACT OF 1977		●	●	●	●			●	●	
FLOOD CONTROL WORKS (USCE)										●
COASTAL ZONE MANAGEMENT ACT	●	●		●	●	●		●	●	
MOBILE HOME CONSTRUCTION & SAFETY STANDARDS ACT OF 1974	●	●		●	●	●				●

Figure 15. Major Disaster-Related Legislation by Policy Typology

Federal Flood Hazard Policies

Of the nine natural hazards examined in this study, riverine floods have received the greatest attention from the federal government. Legislation dealing with riverine floods has included: (1) The Flood Control Act of 1936, et. seq.; (2) The National Flood Insurance Act of 1968; (3) The Flood Disaster Protection Act of 1973; and, (4) The National Dam Inspection Act of 1972.

The first of these acts signalled the beginning of a massive federally-funded effort to reduce flood hazards through construction of dams, levees, floodway improvements, and other similar measures. The flood insurance and flood disaster protection acts signalled a shift in policy and a developing federal awareness that floodplain avoidance measures should be given a priority equal or exceeding the earlier commitment to structural approaches to the problem.

1. Flood Control Act of 1936, et. seq. (Administered by the United States Army Corps of Engineers). The Flood Control Act of 1936 established the Corps of Engineers as the primary agency for the construction of flood control works. This program has been expanded through numerous other legislative actions to become part of a broader responsibility now labelled by the Corps, "water resources development." Under this program, the Corps expended a total of $1.8 billion in fiscal 1974 and $2.1 billion in fiscal 1975 on rivers, harbors, and flood control. In this two-year period the Corps undertook 24 major new flood control projects, and it estimates savings from flood losses generated by its flood control works as $22.5 million during this same two-year period. The Corps estimates cumulative damages prevented by its flood control projects through June 1975 to be $59.5 billion, compared with a federal cost of $10.2 billion for those projects. During fiscal 1975, the Corps worked on constructing 62 flood control lakes in all parts of the United States, and topped out two dams under construction in California. Other projects were for local protection including levees, dikes, flood walls, diversion channels, channel alterations, and pumping and land treatment to protect a local area.

In addition, the Corps provides information, technical and planning assistance, and guidance to communities in identifying magnitude and extent of the flood hazard and in planning wise use of floodplains. The agency issues Floodplain

Information Reports containing flood area maps, tabulations, hydraulic data, and narrative descriptions which include some flood history and estimates of the frequency of future floods. Non-structural alternatives also are part of the activities of the Corps, such as the acquisition of wetlands for natural storage areas and the development of recreation facilities in flood prone lands. (U.S. Corps of Engineers, 1974 and 1975).

2. National Flood Insurance Act of 1968 (PL 90-448); Title XIII of HUD legislation, enacted August 1, 1968, administered by the Flood Insurance Administration and the Secretary of the Department of Housing and Urban Development.

Although the possibility of insurance against flood hazard was considered after virtually every major flood, no federal action to establish such a program was taken until 1968.

Hurricanes and floods in California and the northeast in 1955 led to the enactment of the Federal Flood Insurance Act of 1956 [P.L. 1016, 84th Congress, 70 Stat. 1078], but because of disagreement with the insurance industry and doubts over the effectiveness of the proposals, funds were not appropriated. The Alaska earthquake of 1964 and Hurricane Betsy in 1965 provided the final impetus for federally subsidized flood insurance [U.S. Congress, 1966]. With rising concern over the losses from natural disasters, the increasing volume of federal funds demanded for relief of victims, and the limited success of local communities in managing their flood plains [Platt, 1976], the National Flood Insurance Act of 1968 [P.L. 90-448, Title XIII] was adopted. Through it, the federal government became involved with the land use planning process on non-public lands, in what the Administrator of the National Flood Insurance Program called the "first constructive land use bill in the Nation." [U.S. Congress, 1975].

The land use ramifications of flood insurance programs were recognized by the report to the President from HUD prior to passage of the 1968 Act. [U.S. Congress, 1966]. HUD believed the best long-run solution to losses in the nation's flood plains to be a policy which encouraged a shift in land use from residential to industrial, recreational, or to overflow use.

HUD noted that zoning, building permits, extension of public services, and other public actions could provide guides to private investment which could work toward the same end. In HUD's view, the management of flood-prone areas went beyond flood insurance alone, but it suggested that flood insurance should be a facilitating force toward development and implementation of long-range flood-mitigating land use policies.

Approximately seven percent of the land area of the United States is subject to flooding, and this land is under the jurisdiction of 17,000 local governmental units [Platt, 1976]. A United States Geological Survey study of 26 United States cities has revealed that over half of the flood plain areas of these cities has been developed at urban densities [Schneider and Goddard, 1974]. The USGS study (Table 12) illustrates the extent to which flood plains can cover large portions of urban areas. Of the cities studied, an average of over sixteen percent of their area is within a flood plain. Ten percent of Chicago, about 132 square miles, is subject to flooding, and that area includes some of the most densely developed portions of the city.

Urbanized area	Flood plain		Developed	
	Area (sq.mi.)	Percent of urbanized area	Area (sq.mi.)	Percent of flood plain total
Asheville, NC	1.6	4.4	1.0	65.0
Boise, ID	2.5	8.5	2.1	84.0
Boston, MA	62.4	9.4	11.9	19.1
Charleston, SC	39.8	40.1	21.2	53.3
Chicago, IL	131.8	10.3	75.1	57.0
Dallas, TX	146.1	21.7	28.0	19.2
Denver, CO	30.6	10.5	19.1	62.2
Fargo—Moorhead, ND-MN	9.4	40.0	5.1	54.3
Great Falls, MT	2.0	9.2	1.9	97.0
Harrisburg, PA	9.7	12.4	8.1	83.5
Lansing, MI	4.8	6.5	.9	18.8
Lincoln, NB	13.8	26.5	6.9	49.6
Lorain—Elyria, OH	5.3	5.0	.6	11.3
Monroe, LA	32.5	81.0	26.8	82.4
Norfolk—Portsmouth, VA	59.2	19.8	15.5	26.2
Omaha—Council Bluffs, NB-IA	50.6	33.5	23.1	45.5
Phoenix, AZ	71.2	18.4	63.5	89.2
Portland, OR	14.5	5.4	8.5	58.7
Reno, NV	2.0	5.3	.9	45.0
Richmond, VA	12.9	8.9	1.7	13.2
St. Louis, MO-IL	136.1	29.6	91.7	67.4
Salt Lake City, UT	12.9	7.0	10.1	78.3
San Jose, CA	80.0	28.8	67.9	84.7
Spokane, WA	1.9	2.4	.9	47.4
Tallahassee, FL	3.1	10.4	2.6	83.9
Texarkana, TX-AR	4.7	13.8	2.1	44.2
Total	941.4		497.2	
Weighted average		16.2		52.8

Table 12 - Areas of Selected Urban Flood Plains
[Schneider and Goddard, 1974]

Thus, the Flood Insurance Act of 1968 was adopted, in part, to deal with the problems posed by continued development of the nation's flood plains. Section 1305 states that "flood insurance will be made available in only those states or areas which have evidenced a positive interest in securing flood insurance coverage under the program." Section 1315 states: "After June 30, 1970, no new flood insurance coverage shall be provided under this title in any area...unless an appropriate public body shall have adopted permanent land use and control measures...consistent with the comprehensive criteria for land management and use under section 1361." Section 1361 establishes criteria for land management and use, supporting development of local measures for land use, flood control, flood zoning, and flood damage protection. Procedures include:

(a) Adopting measures to constrict the development of land which is exposed to flood damage,

(b) Guiding the development of proposed construction away from locations which are threatened by flood hazards,

(c) Assisting in reducing damage caused by floods,

(d) Otherwise improving the long-range management and use of flood-prone areas.

This act also authorizes studies to determine "the extent to which insurance protection against earthquakes or other natural disaster perils, other than flood, is not available from public or private sources, and the feasibility of such insurance protection being made available."

The insurance program is managed by the National Flood Insurers Association (NFIA), a pool of insurance companies which sells and services flood insurance, and distributes profits and liabilities to its members. The Federal Government makes premium equalization payments to the insurers' pool to make up the difference between below-cost premiums received and the actuarial cost of the insurance. The federal government supports private firms by guaranteeing to pay claims in excess of the financial capacity of the privately financed pool.

A National Flood Insurance Fund was created with borrowing authority for the Secretary of HUD of up to $250 million. The ceiling on outstanding insurance was placed at $2.5 billion. The Act also made flood insurance available for the first time to owners of flood-prone one to four family dwellings and to small businesses.

Federally subsidized rates totaled about ten percent of actuarial rates, and were available only for existing structures in the flood plain; new structures could only be insured at the actuarial rates, which in fact are prohibitive. Thus, the scheme involves the hope that flood plains will eventually be cleared of structures subject to flood damage. In order for a property owner to purchase federally subsidized flood insurance, the entire community was required to become eligible for inclusion in the program by adopting flood plain management measures adequate to meet HUD standards.

However, two weaknesses in the 1968 Act soon became apparent: (a) the program was voluntary. Although it may have been in the long-term interest of the federal taxpayer to be partially relieved of the disaster relief burden, many communities apparently were little interested in placing a short-term hardship on their residents living in exposed areas; (b) detailed studies of individual communities were required before rates could be determined. The Secretary was to identify flood zones, and within five years after enactment, establish a set of actuarial flood insurance premiums based on the flood-zone statistics. As a result of these limiting factors only four of the nation's 16,000 flood-prone communities became eligible under the program during its first year. [Platt, 1976].

In 1969 Congress set up an emergency program which is still in effect. It allowed communities to take part in the program with reduced amounts of coverage while the lengthy rate-making study was under way. Under the regular program, coverage is double what it is under the emergency program, and premiums are based on actuarially-determined rates. More stringent flood plain management procedures also are required. By May 1973, however, there were only 2,200 eligible communities in the program [U.S. Congress, 1975]. In order for the intent of the program to be carried out, federal spokesmen asserted that all

flood-prone communities would have to participate and this participation was made mandatory by the Flood Disaster Protection Act of 1973 [P.L. 93-234].

3. Flood Disaster Protection Act, 1973 [P.L. 93-234], enacted December 31, 1973 administered by the Flood Insurance Administration (HUD) in cooperation with the National Flood Insurers Association, a pool of 132 major property and casualty insurance companies.

Under the provisions of the 1973 Act, no federally-related financial assistance can be provided for acquisition or development of any identified flood prone property unless: (a) the community in which it is located has entered the National Flood Insurance Program, and (b) the applicant for such financing has purchased a flood insurance policy. Federally-related financing includes direct federal assistance of any kind and also loans by private banks and thrift institutions insured or regulated by federal instrumentalities such as the Federal Deposit Insurance Corporation [Platt, 1976].

Title I contains an expansion of the National Flood Insurance Program and provides for coverage of losses due to erosion and the undermining of shorelines. The bill more than doubled flood damage coverage for homeowners and businesses. Single family dwellings can be insured for up to $35,000, and their contents for up to $10,000. Other residential buildings can be insured for up to $100,000, and their contents up to $10,000. Subsidized low-cost flood insurance is made available at 25 cents per $100 of coverage in most areas, with the federal government paying from 70-90% of the cost.

Title II deals with disaster mitigation requirements. The Secretary of the Department of Housing and Urban Development is required to identify flood-prone communities and notify them of this designation. Upon notification the community must apply for participation in the flood insurance program or prove that it is not flood-prone. The identification of flood prone areas and criteria for land use management are required to be established by the Secretary of HUD in consultation with elected local officials. A community is designated as flood-prone if it has a 1% chance of being vulnerable to a serious flood in any year. Once it is so designated, it has one year to enter the flood insurance program before penalties are imposed.

The bill retained a provision of the 1968 National Flood Insurance Act requiring communities, as a condition of their participation in the insurance program, to adopt land use and control measures to restrain construction projects in areas exposed to possible flood damage.

In signing the bill, President Nixon said he expected it would both help to reduce losses from floods, and to provide faster and fairer assistance to victims than was achieved under previous disaster relief loan programs.

However, the mandatory penalties for noncompliance have stirred a great deal of controversy and opposition. Subsequent amendments have modified certain elements of this bill. Exemptions from the ban on mortgage lending were allowed in PL 94-375 (passed on July 20, 1976) under conditions where loans were:

a) used to purchase a residential dwelling occupied before March 1, 1976,
b) for up to $5,000 to improve existing residences,
c) used to finance the purchase of a building occupied by a small business before January 1, 1976, and
d) used to finance improvements for agricultural purposes on a farm.

The bill was amended again in May 1977 to remove the provision prohibiting federally insured lending institutions from making loans to property owners in HUD designated flood-prone areas which were not participants in the flood insurance program. The amendment instead required lending institution to notify the recipient that he or she would not be eligible for federal disaster relief and that the federal government could not assist individuals who undertook development in flood-prone areas without adequate flood-proofing measures. Despite the controversy surrounding this bill, more than 85% of designated flood-prone communities are participants in the program. Similarly, one official estimate suggests that the floodplain management payoff from the program will produce net federal savings totaling almost two billion dollars per year in 2000 [see Figure 15].

The federal government has encouraged participation in this program on the assumption that insurance and preventive land-use control measures are cheaper than general disaster relief made available after the fact. The Federal Water Resources Council has estimated that the government could save about $1 billion .

A report by the House Public Works Committee (H Rep 92-1232) supporting the passage of the act noted that state programs for licensing and inspection of non-federal dams varied greatly in scope and effectiveness. It cited the dam failures at Buffalo Creek, West Virginia, and Rapid City, South Dakota, as examples of disasters which might be prevented by passage of the bill.

The report said the bill would "provide an accurate assessment of the scope of the problems and an appropriate sharing of responsibility between federal, state and local governments and public and private interests." The estimated cost of the program was $90 million.

However, the implementation of this bill was delayed after its passage, due to the assignment of a relatively low priority by the executive branch.

A major disaster due to dam failure occurred with the collapse of the Teton Dam in Idaho on June 5, 1976. Eleven people died, 1,000,000 acres were destroyed, 16,000 head of livestock killed, and $1 billion lost in property damage. Payment of claims arising from the disaster cost the U.S. $549 million. This was a Bureau of Reclamation project and thereby exempt from the dam inspection legislation. It was, however, the first dam failure in the Bureau's 75 year history. The investigation panel of the House Government Operations Committee issued a report (H Rep 94-1667) on September 23, 1976, with the findings:

a) There exists within the Bureau of Reclamation a "bureaucratic momentum" to build dams, and that once construction is begun the decision to halt construction is no longer an option. Safety problems are generally met with unquestioned reliance on the Bureau's abilities to "engineer" workable solutions.

b) The Bureau was deficient in its examination of the geologic site of the Teton Dam.

c) The Bureau was deficient in responding to warnings that the site might be dangerous.

d) The United States Geological Survey was deficient in withholding information about geologic hazards at the Teton Dam site from the Bureau for six months.

annually if all flood-prone communities engaged in floodplain management and if all of their residents were insured.

In summary, the National Flood Insurance Program is intended to reduce economic and other losses due to floods, and was implemented as a result of rising costs to the federal government in providing relief to flood victims. Although it was not intended directly as a federally-monitored land use program, in effect, the mandatory nature of the program after 1973 has put the federal government in the position of establishing performance standards for land uses and building construction requirements in floodplains. The 1977 amendments, however, reduce some of the action-forcing authority of the federal government.

One consequence of the National Flood Insurance Program has been the organization of groups opposed to required flood insurance. The Flood Insurance Litigation Coalition has been formed to challenge the constitutionality of the Flood Disaster Protection Act of 1973. The coalition was largely coordinated by the Texas Landowners Rights Association and residents of the City of Cape Girardeau, Missouri. By March 1977, seven months after the coalitions' founding, a total of $164,000 in contributions had been received, and litigation challenging the Act was under preparation when the 1977 amendments were adopted to remove the mandatory insurance requirements for individual property owners.

4. National Dam Inspection Program (PL 92-367) enacted August 8, 1972 and administered by the Secretary of the Army.

This bill authorizes the Secretary of the Army to carry out a national inspection program aimed at more than 28,000 non-federal dams in the United States. It does not apply to dams under the jurisdiction of the Bureau of Reclamation, the Tennessee Valley Authority, the International Boundary and Water Commission, or the Federal Power Commission; dams which were inspected in the past 12 months; or dams which pose no threat to human life or property. The Secretary was directed to issue a report to Congress by July 1, 1974 which would include an inventory of all dams, a review of inspections and recommendations and a suggested national program for dam safety regulation.

Although this report and the disaster did not result in any legislative action, President Carter reactivated the 1972 Dam Inspection Program on November 28, 1977 [Los Angeles Times, 1977]. Earlier that year, Congress took the initiative and voted $15 million for federal inspection of private dams, but it was the November 5 collapse of a never-inspected dam near Toccoa, Georgia, that led President Carter to implement this program. Inspections were to be carried out by the Corps of Engineers; 2,000 dams can be checked with the $15 million congressional appropriation. The president indicated he was committed to a multi-year program so that all high hazard dams could be inspected within the next four years. His administration seeks to encourage states to share responsibility for inspection. California's Dam Safety Program was cited as exemplary. It involves expenditure of about $2 million annually for inspection and regulation of more than 1,000 private, municipal and state-owned dams.

In addition to the above cited statutory measures, two executive orders particularly address the flood hazard. Executive Order 11988, issued May 24, 1977, requires that each federal agency shall, through its normal activities, "provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains." The executive order sets forth specific procedures for federal agencies to observe in carrying out this policy. Executive Order 11990, of the same date, requires similar consideration for wetlands.

Federal Policies for Mitigation of Coastal Hazards

Mitigation of the effects of coastal natural hazards is one of several objectives of the Coastal Zone Management Act of 1972 (P.L. 92-583). Among the elements required to be addressed in the coastal plans required by the Act is the issue of "floods and flood damage prevention, erosion (including the effect of tides and currents upon beaches and other shoreline areas), land stability, climatology and meteorology" (Federal Register, January 9, 1975, p. 1685, section 923.4). To meet this and other coastal planning objectives, Congress requires each coastal state to submit a proposed management program in order to qualify for administrative grant assistance under Section 306 of the

Coastal Zone Management Act. Proposed programs are required to employ the following techniques for control of land and water uses within the coastal zone:

1) State establishment, review, and enforcement of criteria and standards for local implementation.

2) Direct **state** land and water use planning and regulation; and/or

3) State administrative review for consistency with the management program of all development plans, projects, or land and water use regulations...

In the Coastal Zone Management Act Amendments of 1976 (PL 94-370 Section 4) Congress required state "306 plans" to provide a planning process for assessing the effects of shoreline erosion, for studying ways to lessen the impact of erosion, and for the restoration of eroded areas. [NOAA, 1976]

Nine natural hazards are of particular concern to NOAA under the Coastal Zone Management (CZM) Act. In a 1976 report, Natural Hazard Management in Coastal Areas, NOAA notes the status of public policy with respect to these hazards, and the consequent role to be played by CZM:

1. Hurricane: More than 6 million* people are currently exposed to hurricane storm surge in areas where the population is growing at a rate 3 to 4 times as fast as the national average. Although warning systems are improving, expanding occupancy of vulnerable areas and the lack of hurricane experience by young persons and relative newcomers results in an enlarging native population and volume of property subject to damage. Hurricane winds and tornadoes may extend the impacts to much larger populations.

2. Flood: Valleys subject to fresh water flooding frequently enter the coastal zone and in some places have been protected by engineering works. The requirements of the Flood Insurance Act for local land use planning in vulnerable areas have spurred the delineation of flood hazard lands and the enactment of

*For the baseline year of 1970 this study shows that 9.9 million people and 104 trillion collars of building value were exposed to storm surge flooding. [Petak, Atkisson, Glye, 1978]

local land use regulations to curb the increasing trend toward expansion of property in lands subject to floods with annual recurrence probabilities of one percent.

3. Coastal Erosion: Coastal erosion is significant along a quarter of the national shore front, and in as many as 2,700 miles it is a critical problem. In addition to protective works, dune stabilization, and beach nourishment, a wide range of land use controls is available to cope with continued erosion. Currently there is a shift in emphasis toward land use management as an alternative strategy to erosion control.

4. Landslide: Although landslides can occur widely, there is no explicit national policy for dealing with this hazard. Only recently and in a few states has there been extensive effort to combine land management with abatement of landslide.

5. Earthquake: Accurate and consistent earthquake prediction has not yet been demonstrated. Other measures which promise major reduction in vulnerability to earthquake damage include the requirement of earthquake resistant construction, land use management, and preparedness planning. For most of the vulnerable areas of the country, and particularly those away from the Pacific Coast, little progress has been made in incorporating these measures into earthquake loss reduction planning.

6. Tsunami: Except for an improved warning system and for pioneering efforts in Hawaii, there has been relatively little action in reducing vulnerability to tsunami waves. The amount of property and number of lives susceptible to this rare, but catastrophic, hazard is mounting.

7. Volcano: The lava flows in Hawaii are relatively well-defined and subject to prediction. Pyroclastic flows and ash flows resulting from violent eruptions are more or less predictable, are less frequent, and constitute a large, but rare, threat along the Pacific Coast and Alaska.

8. Avalanche: In a few parts of Alaska, snow avalanche is a significant hazard, and only recently has there been serious consideration of a variety of

measures, including land management, to deal with them.

9. Land Subsidence: In parts of both the California and Gulf coasts there is threat of increasing vulnerability to natural hazards from land subsidence resulting from pumping of water, oil and gas.

In developing state policies for the mitigation of these natural hazards, NOAA [1976] recommends the following general types of action by the individual states:

1) Hazard areas along each section of the coast should be designated.

2) Coastal management offices should assure that all parties concerned are aware of the range of adjustments to a hazard and of the costs and benefits related to each adjustment.

3) Efforts should be made to find out which channels of information about hazards have higher credibility in the view of the people for whom the information is designed, and those channels should be used for disseminating information about the hazard.

4) Descriptions of the proposed change in adjustments to hazards also should discuss the existence or creation of the necessary powers to promote the new work within state or local agencies. Specific consideration should be given to ways in which planning for natural hazards in coastal areas can be linked with emergency planning for disasters under Section 201 of the Disaster Preparedness Act of 1974.

The Coastal Zone Management Act is intended to provide an opportunity for state coastal zone management agencies to find effective ways of applying to coastal areas the concepts, information, and analytical methods previously developed in natural hazard studies. To do so, according to NOAA, can reduce the vulnerability of the nation to catastrophe and enhance the resilience of land and water uses along the coast.

Federal Policies for Disaster Relief:

Federal policies on this subject are contained in: Disaster Relief Act, 1974 [P.L. 93-288], enacted May 22, 1974, and administered by the Federal Disaster Assistance Administration [FDAA].

This legislation is aimed at alleviation of the suffering and damage which result from disasters, and provides federal assistance for both public and private parties who experience losses in disasters. It further provides for development of long-range recovery programs for major disaster areas.

The Act applies to major catastrophes, defined as: hurricane, tornado, storm, flood, high water, wind-driven water, tidal wave, tsunami, earthquake, volcanic eruption, landslide, mudslide, snowstorm, drought, fire, explosion, or other catastrophe which is so determined by the president. Federal assistance to disaster areas is initiated upon declaration by the president that a major disaster or emergency exists in a specified place. Although primarily concerned with providing post-disaster relief, this bill contains some disaster mitigation measures.

Under the Act, states and local governments are encouraged to apply for and may receive up to $250,000 for the development of a comprehensive program for disaster preparedness and prevention, including mitigation, warning, emergency operations, rehabilitation, recovery, application of science and technology, and research. It also provides for development of an effective disaster warning program, utilizing Civil Defense or other communications systems. This element aims at improving disaster relief by supporting better coordination and responsiveness among existing disaster relief programs. The preparation of disaster preparedness plans was first written into the Disaster Relief Act of 1969; as of September 1976, all but one state was utilizing federal funds for these studies.

Also, states, local governments and individuals are encouraged by the Act to protect themselves by obtaining insurance coverage to supplement or replace government assistance. Owners of property which has been repaired or restored with federal disaster relief funds are required to obtain disaster insurance as a condition for receiving future federal disaster assistance. This requirement

does not apply to individual homeowners, but only to state and local governments, non-profit institutions and public works projects.

The question of insurance was raised in a Senate committee report on the implementation of the 1969 Disaster Relief Act following Hurricane Camille. A special subcommittee on Disaster Relief, under the Senate Public Works Committee and chaired by Birch Bayh (D-Indiana) recommended some form of all-risk insurance. Testimony taken by the committee indicated that existing insurance coverage was inadequate protection against disasters like Camille, and it was suggested that such programs might have to be supervised and financed by the federal government. Property insurance coverage for extreme natural events also was recommended in President Nixon's message to Congress on disaster relief and Hurricane Camille (April 22, 1970).

The Act encourages use of hazard mitigation measures to reduce losses from disasters, including development of land use and construction regulations. It requires the reconstruction or replacement of federal facilities to be evaluated with regard to natural hazard exposure. In particular, the Act requires that any loans or grants made under these provisions shall be made with regard to mitigating natural hazards through safe land use and construction practices. Under this provision, the FDAA provides technical assistance regarding codes, standards, and specifications for the repair or reconstruction of public and private structures.

Other major provisions of the Act require or authorize: appointment of a federal coordinating officer to operate in the affected area; mobilization of federal personnel as emergency support teams; assistance of federal agencies in distributing food, supplies and medicine, removal of debris, etc.; use of local firms for assistance and recovery work; nondiscrimination in disaster assistance; priority for public housing assistance; repair and restoration of damaged public facilities; temporary housing assistance; unemployment assistance and increased benefits; relocation assistance; family and individual counseling for mental stress; and loans and grants to local governments for economic recovery.

Amendments and supplemental appropriations are occasionally added to deal with

special situations. Disaster relief amendments (PL 92-209) provide federal financial assistance for private nonprofit medical care facilities damaged or destroyed by major disaster after January 1, 1971. This amendment made available to these facilities the same type of grants offered to publicly owned facilities and resulted from the damage to seventeen hospitals in the Los Angeles area after an earthquake in February, 1971.

Another extension of benefits to the private sector was a 1972 enactment to permit tax deductions for disaster losses (PL 92-418). Persons who suffer property losses in the first six months of a taxable year due to an event in a presidentially declared disaster area are authorized to file an amended federal income tax return for the previous year, claiming uninsured losses as a deduction.

Payments for the period 1953 to 1973 under this and preceding acts are shown in Table 13.

	AGENCY	AMOUNT
1.	Federal Disaster Assistance Administration (FDAA), formerly Office of Emergency Planning and Office of Emergency Preparedness (OEP)	$1,844,827,290
2.	Small Business Administration	809,254,922
3.	Farmers Home Administration	448,180,766
4.	Department of Agriculture	18,415,159
5.	Federal Highway Administration, formerly Bureau of Public Roads	484,637,000
6.	U. S. Army Corps of Engineers	299,341,940
7.	Veterans' Administration	2,000,000
8.	Office of Education	102,330,691
9.	Federal Insurance Administration	46,774,000
	Total	$4,051,761,768

(U. S. Senate, 1974, p. S2221)

Table 13. Direct Federal Expenditures for Disaster Assistance, 1953-1973
[Cochrane, Harold C., 1975]

Federal Earthquake Policies

The major source of policy in respect to this subject is the Earthquake Hazards Reduction Act (PL 95-124), enacted October 1977.

This Act recognizes earthquake as a major natural hazard and deals with prevention and mitigation methods in a comprehensive way. It authorizes appropriation of $250 million over three years to develop both improved methods of earthquake prediction and improved building and land use standards for use in earthquake-prone regions.

Both the Senate and House versions of the bill authorized $102.5 million for the earthquake research budgets of the United States Geologic Survey (USGS) and the National Science Foundation (NSF). The House bill also provided $5 million for other participating agencies, while the Senate put no ceiling on these authorizations. The House bill also included language designed to increase participation through an advisory committee.

The Act requires:

1) An implementation plan to carry out a national earthquake hazards reduction program. The plan, to be prepared by the executive branch is to ensure informed coordination of land use, building design, public information, insurance, warning and relief activities by federal, state and local agencies. Eight federal agencies are to be involved in the plan in addition to the USGS and the NSF. The target date for a functioning program is 1985.

2) Research by USGS and NSF into earthquake prediction, causes and mechanisms of earthquakes, zoning guidelines, preparation of seismic risk analysis for emergency planning, developing earthquake mitigation techniques in man-made structures and in social and economic adjustments.

The main objectives of the bill are:

1) Development of earthquake resistant construction and design methods for public and high occupancy buildings in areas of seismic risk.

2) Development of procedures for identifying seismic hazards and predicting damaging earthquakes.

3) Coordination of information about seismic risk with land use policy decisions and building activity.

4) Development of improved methods for controlling the risks from earthquakes and planning to mitigate such risks; also planning for reconstruction and redevelopment after an earthquake.

5) Public education regarding earthquake and ways to reduce the adverse consequences should an earthquake occur.

6) Development of research on utilization of scientific and engineering knowledge to mitigate earthquake hazards. The social and economic, legal and political consequences of earthquake prediction, and ways to assure the availability of earthquake insurance or some functional substitute.

7) Development of research applied to control or alteration of seismic phenomena.

In a report to the U.S. House of Representatives (proposing adoption of the bill), the Committee on Science and Technology (May 11, 1977) stated:

> Of all the potential mechanisms to avoid earthquake hazards, the simplest and most direct would be zoning. Although cities cannot be relocated and undeveloped high-risk areas may be potentially very valuable, several courses of zoning action may be feasible:
>
> 1. Risk zoning of critical parts of already developed areas to turn them into park land or other nonhazardous use as opportunity arises.

2. Risk zoning of high risk undeveloped areas to prevent future hazardous development.

3. Development of systematic techniques for collection and evaluation of data for use in microzoning (zoning of comparatively small areas) and the establishment of criteria for microzone levels of risk.

4. Adoption of building codes which require higher levels of earthquake resistance in higher risk areas.

Since many areas of high seismic risk are already heavily developed and populated, the promotion of earthquake resistant building practices is receiving priority consideration as an effective approach to minimize earthquake damages from ground movement, which causes over 90 percent of the damages. Even if an earthquake is anticipated and residents have evacuated the area, there is still a need to reduce the damage to buildings and other facilities. If there has been no advance warning and no evacuation, the need for safer building is obviously critical.

Since the greatest earthquake hazards result from inadequacies in building construction, this is obviously an area in need of close attention. The current state of the art in defining seismic design criteria and in earthquake resistant construction techniques leaves much to be desired. Therefore, additional research to advance the state of the art is of critical importance. Buildings not constructed in accord with adequate design provisions should be evaluated and, if found to be hazardous, should be strengthened or replaced. So that new construction should not add to the earthquake hazards, seismic design criteria providing appropriate resistance should be incorporated in building regulations and enforced.

The costs of adopting building standards designed to reduce earthquake hazards vary considerably. Witnesses estimated that the implementation of seismic standards increase new building costs one to six percent.

The costs can run much higher for special buildings such as hospitals. The earlier earthquake resistance is introduced into the construction process, the less the cost increase.

Advocates of the legislation contended it was needed because more and more Americans live in high-risk areas on both coasts; because scientific advances make accurate prediction a real possibility; and because seismological data is needed to evaluate site selection for nuclear power plants. A prime example cited was the Diablo Canyon, California, nuclear power plant. In 1971, after work was well under way on the billion-dollar plant, a potential active fault was discovered under nearby coastal waters. An expert testified that the fault could produce an earthquake about double the intensity that the plant was originally designed to withstand. The utility company is now reanalyzing its design.

Although the debate over the proper approach to earthquake mitigation continues, the Act offers the opportunity to search for far-reaching answers to the earthquake threat in the United States.

Other Federal Hazard-Related Policies

In addition to the major policies examined above, the federal government administers numerous other hazard-related programs. Figure 16 is a summary of current federal programs relating to each of the nine natural hazards studied in the current project. Included are predisaster functions (emergency preparedness to mitigate the effects of the disaster), post-disaster functions (emergency preparedness for disaster relief), and natural disaster warning activities.

For example, the Farmers Home Administration (Department of Agriculture) administers Watershed Protection and Flood Prevention Loans; program number 10.419 in the Catalog of Federal Domestic Assistance. The "Uses and restrictions" of such loans, as described in the Catalog, read in part:

> "Loan funds may be used to help local sponsors provide the local share of the cost of watershed works of improvement for flood prevention, irrigation, drainage, water quality management, sedimentation control, fish and wildlife development, public water based recreation and water storage and related uses."

This program is indicated in Figure 16 as having a pre-disaster function (disaster mitigation) for riverine floods. Although there seems to be no prohibition in the program description against funds being used for storm surge mitigation, this use would seem to be highly unlikely and therefore it is not so indicated. FmHA also administers emergency loans "to assist farmers, ranchers and aquaculture operators with loans to cover losses resulting from a national disaster," which includes natural disasters. These loans are a post-disaster function, to provide disaster relief for victims.

Other agencies with programs in flood hazard mitigation include the Bureau of Reclamation and the Soil Conservation Service, as well as some regional agencies such as the Tennessee Valley Authority. Most other federal programs appear to be directed toward disaster relief with the exception of

FEDERAL AGENCY OR ACTIVITY	PROGRAM	PROGRAM NUMBER	EARTHQUAKES	HURRICANE WINDS	TORNADOES	TSUNAMIS	LANDSLIDES	RIVERINE FLOODS	STORM SURGE	SEVERE WINDS	EXPANSIVE SOIL
Farmers Home Administration (DOA)	Emergency Loans	10.404	□		□	□	□		□		
	Watershed Protection and Flood Prevention Loans	10.419						■			
Agricultural Stabilization and Conservation Service (DOA)	Emergency Conservation Measures	10.054	□	□						□	
Soil Conservation Service (DOA)	Resource Conservation and Development	10.901						■			
	Water Shed Protection and Flood Prevention	10.904						■			
Agriculture Research Service (DOA)								R			
Economic Research Service (DOA)								R			
U.S. Forest Service (DOA)								■			
Economic Development Administration (DOC)								R		-	
Bureau of Economic Affairs (DOC)	Technical Services							■	■		
Department of the Army Office of the Chief of Engineers (DOD)	Flood Control Works (Rehabilitation)	12.102		□		□		□	□	□	
	Flood Fighting and Rescue Operations	12.103						□	□		
	Flood Plain Management Services	12.104						■	■		
	Emergency Bank Protection	12.105						□			
	Small Flood Control Projects	12.106						■	■		
	Snagging and Clearing	12.108						■	■		
	Planning Assistance to States	12.110						■	■		
	Dam Inspection							■			
Public Health Service (HEW)	Emergency Medical Service Planning	13.284	□	□	□	□	□	□	□	□	
Housing Protection and Mortgage Credit/FHA (HUD)	203h: Mortgage Insurance: Disaster Victims	14.119	□	□	□		□	□	□	□	
Federal Disaster Assistance Administration (HUD)	Disaster Assistance	14.701	□	□	□	□	□	□	□	□	
Federal Insurance Administration (HUD)	National Flood Insurance Program	14.001	-		:		■*	■	■		
Defense Electric Power Administration (DOI)	Electric Power Planning for Emergencies	USGM 281	□	□				□		□	
Bureau of Reclamation (DOI)	Reclamation Projects	15.504						■			
Bureau of Land Management (DOI)								■			
Bureau of Outdoor Recreation (DOI)	Grants & Loans							■	■		
Forests & Wildlife Service (DOT)								R			
U.S. Coast Guard (DOT)								□	□		
Federal Aviation Administration (DOT)								■	■		
Federal Highway Administrations (DOT)								■	■		
Federal Railway Administrations (DOT)								■	■		
National Science Foundation	Basic Research	47.000-47.052	R	R	R	R	R	R	R	R	R
Small Business Administration	Loans to Natural Disaster Victims	59.008	□	□	□	□	□	□	□	□	
Tennessee Valley Authority	Water Resources Development	62.003						■			
Federal Crop Insurance Corp. (DOA)	Crop Insurance	10.450		□				□			
U.S. Geological Survey (DOI)	Prediction		■			■	■	■			
National Weather Services (NOAA)	Hazard Warnings			■	■	■		■	■	■	
National Meterological Center (NOAA)	Hazard Warnings				■						
National Science Storm Forecast Center (NOAA)	Hazard Warnings				■						
Radar Report and Warning Coordination Circuit(NOAA)	Hazard Warnings			■	■						
GOES - Satelite System (NOAA)	Hazard Warnings			■	■	■					
National Hurricane Center (NOAA)	Hazard Warnings			■							
National Tsunami Warnirg Center (DOI)	Hazard Warnings					■					
Office of Coastal Zone Management (NOAA)	Coastal Hazard Mitigation: 11.418-11.424		■	■			■	■	■	■	

Legend:

■ Programs with pre-disaster functions (disaster mitigation)
□ Programs with post-disaster functions (disaster relief)
R Programs with natural hazard research functions

*mudslides only

Figure 16. Current Federal Programs Relating to Natural Hazards

those administrated by the National Science Foundation and the U.S. Geological Survey, which sponsor basic and applied research. Disaster relief programs include loans to victims, insurance for crops and buildings, emergency physical rehabilitation programs, and planning for disaster preparation.

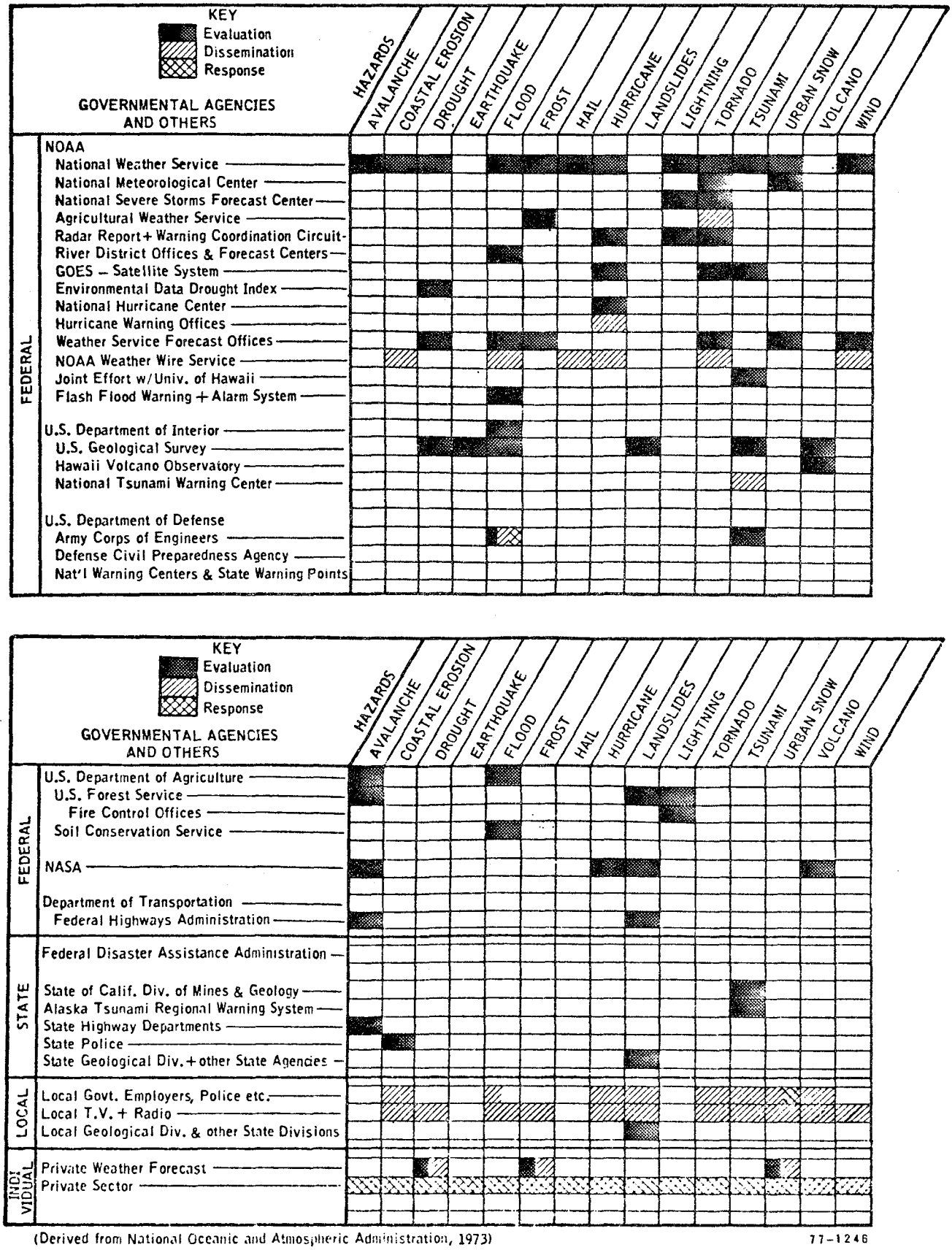
The federal government, particularly the National Oceanic and Atmospheric Administration, also provides warnings for five of the hazards studied here, (floods, hurricanes, tornadoes, tsunami, and severe wind). Although no earthquake warning system has been developed, the U.S. Geological Survey is performing significant research in this field and currently provides data relative to earthquake and landslide-prone areas. Storm surge warnings are included as hurricane warnings. No warning is provided for expansive soil, since it poses no sudden and unexpected threat. Figure 17 provides perspective on current warning systems and the NOAA administrative units concerned with specific hazards.

Proposed Federal Emergency Management Agency

On June 19, 1978, President Carter proposed the creation of a Federal Emergency Management Agency. When implemented, this measure will merge five agencies into one new agency: The National Fire Prevention and Control Administration; the Federal Insurance Administration; the Defense Civil Preparedness Agency; the Federal Disaster Assistance Administration; and the Federal Preparedness Agency.

Several additional transfers of emergency preparedness and mitigation functions would be made to the new agency, including oversight of the Earthquake Hazards Reduction Program (now under the Office of Science and Technology Policy of the Executive Office of the President); the federal emergency broadcast system; the federal dam safety program; and the program which provides assistance to communities in the development of readiness plans for severe weather-related emergencies, including floods, hurricanes, and tornadoes. The new agency will also be responsible for coordination of natural and nuclear disaster warning systems; and coordination of preparedness planning to reduce the consequences of major terrorist incidents.

According to the president's proposal, this reorganization is based on the principles that: (a) federal authorities responsible for actions related to



Source: (Mileti, 1975, pp. 28-29)

Figure 17 – Current Government Programs for Natural Hazard Warnings

major civil emergencies should be supervised by one official responsible to the president; (b) an effective civil defense system requires the most efficient use of all available emergency resources; (c) emergency responsibilities should, whenever possible, remain within the regular missions of federal agencies; (d) federal hazard mitigation activities should be closely linked with emergency preparedness and response functions.

The proposal suggests that cost savings of from $10 to $15 million annually can be expected, without significant reductions in program expenditures for the transferred agencies and authorities.

State Land Use Policies

Although state level policies which specifically address natural hazards are relatively limited in number, all states have adopted land use policies which may serve as a framework for natural hazard mitigation. J.A. Kusler [1976] has summarized and analyzed state statutes authorizing local governments and state agencies to adopt zoning regulations, subdivision controls, building codes, and special flood hazard regulations, with emphasis on land use control for the regulation of flood-prone areas. The Seventh Annual Report of the Council on Environmental Quality [1976] summarized state land use and planning authority in categories complementary to those devised by Kusler. The CEQ noted that, by mid-1976, most states had an active interest in land use controls -- something that was rare only five years earlier when The Quiet Revolution in Land Use Control was published by CEQ as a review of "pioneering efforts of a few states and regions to restructure government and to fashion policies for improving land development decisions."

Developed from the Kusler and CEQ reports, **Figure** 18, summarizes the current statutory authority of the fifty states with respect to land use policy, with special reference to flood mitigation authority. In general, the following situation prevails:

1. General Authorization - All states have authorized the adoption of zoning regulations, but only twenty have adopted requirements for subdivision regulations at the state level. Typically, these statutes require or allow the adoption of subdivision regulations by local government units under certain statewide

STATE	GENERAL AUTHORIZATION		HOME RULE POWERS		EXTRATERRITORIAL CONTROLS			PRIOR PLANNING REQUIREMENTS			ENABLING AUTHORITY FOR ADOPTION OF INTERIM REGULATIONS		SENSITIVE LAND USES INCLUDED IN REGULATIONS								COMPREHENSIVE PERMIT SYSTEM	COORDINATED INCREMENTAL PLANNING	MANDATORY LOCAL PLANNING	DIFFERENTIAL ASSESSMENT LAWS	STATUTES AUTHORIZING ADOPTION OF FLOOD PLAIN REGULATIONS BY STATE AGENCIES	LOCAL FLOOD HAZARD REGULATIONS SPECIFICALLY AUTHORIZED			STATE
													SUBDIVISION			ZONING													
	SUBDIVISION	BUILDING CODE	GENERAL	SPECIAL REFERENCE TO LAND USE	SUBDIVISION	ZONING	BUILDING CODE	COMPREHENSIVE PLAN FOR ZONING	COMPREHENSIVE PLAN FOR SUBDIVISION	FLOOD OR DRAINAGE LANGUAGE	ZONING	SUBDIVISION	PUBLIC UTILITIES	AGRICULTURE	LARGE LOTS	AGRICULTURE	NON-CONFORMING USES REGULATED	WETLANDS	POWER PLANT SITING	DESIGNATION OF CRITICAL AREAS						ZONING	SUBDIVISION	BUILDING CODE	
AL		●	●	●	●			●	●	●				●	●	●			●					●			●			AL
AK													●	●	●	●			●			●		●			●	●		AK
AZ	●		●		●	●				●			●						●			●		●		●	●	●	●	AZ
AR					●	●				●			●	●	●	●			●					●		●	●	●	●	AR
CA	●	●	●		●			●		●	●		●			●	●		●			●		●		●	●			CA
CO	●		●		●			●	●	●	●		●	●	●	●			●	●				●		●	●	●	●	CO
CT		●	●					●	●	●			●	●	●	●		●	●			●		●		●	●			CT
DE			●					●					●			●		●				●		●			●			DE
FL	●	●	●			●		●	●				●	●		●	●	●	●	●	●	●	●	●			●	●		FL
GA	●	●	●	●	●	●		●	●	●			●	●			●	●				●					●			GA
HI	●							●					●	●	●	●			●	●	●	●		●		●	●	●	●	HI
ID			●		●			●			●	●	●				●						●			●				ID
IL			●		●	●				●									●							●	●	●	IL
IN		●			●	●			●	●			●	●	●	●	●					●				●	●	●	●	IN
IA	●	●	●	●	●	●		●					●	●	●		●									●	●			IA
KS	●		●		●	●		●	●				●	●	●											●	●			KS
KY					●	●		●	●	●	●	●							●							●	●			KY
LA			●	●				●		●			●		●	●	●	●									●	●	●	LA
ME	●	●	●					●	●				●	●		●	●	●	●	●	●	●	●			●				ME
MD		●	●	●	●			●	●	●			●		●		●	●	●	●		●				●		●		MD
MA		●	●										●	●	●	●		●	●							●	●	●		MA
MI	●		●	●				●	●	●	●		●	●		●										●	●	●		MI
MN	●	●	●		●	●		●			●		●	●	●	●		●	●	●		●				●	●	●		MN
MS								●					●		●		●	●								●				MS
MO			●		●	●		●	●									●	●							●				MO
MT	●	●			●	●	●	●		●	●		●						●	●		●	●	●		●	●			MT
NE			●		●	●	●	●	●				●	●		●			●			●	●	●		●				NE
NV	●	●	●					●		●			●			●	●		●	●		●	●	●		●	●			NV
NH								●			●		●	●	●	●		●	●					●				●		NH
NJ			●		●	●		●		●			●			●		●	●					●		●	●	●		NJ
NM	●				●	●	●	●		●			●	●	●	●	●		●			●		●		●	●			NM
NY	●	●	●					●		●			●	●	●	●	●	●	●	●	●	●		●		●	●	●	●	NY
NC		●			●	●	●	●					●	●			●	●				●		●		●	●			NC
ND	●				●	●		●	●				●	●	●				●								●			ND
OH		●	●		●			●	●				●	●					●							●				OH
OK			●					●	●	●			●		●											●				OK
OR	●	●	●		●	●		●			●		●	●		●			●	●		●	●			●		●		OR
PA			●					●		●			●			●	●	●	●	●						●		●		PA
RI		●	●					●					●	●	●	●		●	●			●				●				RI
SC		●			●			●	●	●			●	●		●	●		●							●	●			SC
SD					●	●		●	●	●	●		●	●	●	●	●			●							●				SD
TN		●	●		●	●			●				●	●	●				●								●	●		TN
TX			●	●	●			●					●		●	●	●	●								●	●	●	●	TX
UT			●					●	●	●	●		●		●	●	●					●				●	●	●	●	UT
VT	●							●		●	●	●	●	●	●	●	●	●	●		●	●		●	●	●	●	●	●	VT
VA		●			●					●			●	●	●	●		●					●	●		●	●		VA
WA	●	●	●		●			●			●		●	●		●	●	●				●				●	●	●		WA
WV			●	●					●	●			●	●	●											●	●			WV
WI	●	●	●		●	●		●		●	●		●	●	●	●		●	●	●		●				●	●			WI
WY					●			●	●				●	●	●	●			●			●	●	●						WY

SOURCE: STATUTORY LAND USE CONTROL ENABLING AUTHORITY IN THE FIFTY STATES AND SEVENTH ANNUAL REPORT OF THE COUNCIL OF ON ENVIRONMENTAL QUALITY WASHINGTON D.C.: GPO, SEPTEMBER 1976
Prepared for the Federal Insurance Administration
by J.A. Kusler Associates
Pulbication No. HUD-FIA-179; September 1976

Figure 18 - Land Use and Building Code Authority in The States

guidelines. Thirteen of the states refer to the Interstate Land Sales Act (Arizona, California, Colorado, Florida, Georgia, Hawaii, Iowa, Kansas, Minnesota, New York, North Dakota, Oregon and Washington). To the extent that natural hazard policy is to be established at the state level, many important provisions can be inserted into existing statutes within the current regulatory framework, without having to prepare and adopt a basic legislative package.

2. Home Rule Powers - Thirty-four states have allowed home rule for at least some local government units, and eight of these states make special reference to land use regulation in their home rule statutes. Some other states grant special powers to their largest cities. Home rule can be important for communities in adopting flexible and sensitive natural hazard mitigation policies for their jurisdiction.

3. Extraterritorial Controls - Of the fifty states, 31 grant extraterritorial subdivision controls to their municipalities, generally extending three to five miles beyond corporate limits. Twenty-one states grant extraterritorial zoning controls to their municipalities. In a few states, there is concurrent jurisdiction between municipalities and counties, and in others the county government has primary responsibility for subdivision and zoning. Four states which authorize both extraterritorial zoning and subdivision controls also authorize extraterritorial building code authority.

4. Prior Planning Requirements - In 32 states, zoning is required to be in accordance with a comprehensive plan, and ten states require even more explicit planning prior to the adoption of zoning regulations. Twenty-two states require a comprehensive plan, master plan, or at least a street or transportation plan prior to the adoption of subdivision regulations. Twenty-seven states include specific flood or drainage language in their comprehensive plan enabling authority. In practice, however, a comprehensive planning requirement is nearly universal in the United States, since it has been an integral part of the HUD 701 planning process.

The Model State Zoning Enabling Act, published by the U.S. Department of Commerce in 1926, directs that zoning shall be "in accordance with a comprehensive plan,"

and municipal zoning ordinances typically have incorporated this terminology. A comprehensive plan for a municipality is important for several reasons beyond that of generally promoting "orderly development." Kusler [1976] points out that the extent of encroachment allowed in a floodplain depends partly on the availability of land elsewhere for similar purposes. If land elsewhere is available for, say, industrial uses, such should be excluded from floodplains even if the buildings could be floodproofed. Second, land uses in areas surrounding a critical area for natural hazards may help to define the boundaries of high risk areas. Again, it is a matter of relating the level of restrictions to the potential for loss resulting from a given occurrence of a natural event.

In addition, a comprehensive plan may specify density of development and, to a certain extent, building types, to support development which will be less susceptible to damage during a given type of natural disaster. Also, the circulation element in a comprehensive plan can help assure that the street network will not easily be disrupted in an emergency.

5. Interim Regulations - Several states permit local jurisdictions to adopt interim regulations. Ordinances which suspend all development for a specified period of time are the most common regulations of this type. Such ordinances, sometimes called "Holding Zones," establish that no new development may take place in a given area for a period ranging from six months to two years, until a comprehensive plan or acceptable compromise development plan can be adopted. Fourteen states authorize some type of interim zoning regulations, and three states have similar authority for subdivisions. Florida allows the adoption of interim regulations with respect to building codes. Interim regulations can be particularly helpful in a period of transition, when a municipality or county is attempting to prepare equitable regulations in the face of increasing development pressures or citizen controversy with respect to a hazard-prone area. Even without specific interim regulation authority, however, the zoning power generally allows for the designation of low-density special permit zoning districts, which can serve a similar purpose if adopted prior to protracted controversy surrounding a site or development plan.

6. Sensitive Land Uses - In addition to the general procedural and substantive regulations discussed above, detailed application of regulations to

certain sensitive land uses can be directly applicable to natural hazard mitigation (such as the siting of power plants in hurricane, earthquake, and other hazard zones). In addition, some zoning and subdivision regulations specifically exempt uses such as public utilities or agriculture. Procedurally, such exemptions can offer precedent for excluding important land uses from natural hazard mitigation policy based on land use criteria.

From state subdivision enabling authority, four states exclude certain public utilities. These exemptions are significant because, as Kusler [1976] points out, public utility uses such as roads, bridges, and levees are major offenders in blocking flood flows. They can also pose threats in an earthquake and other extreme natural events. Seventeen states exempt agricultural uses from subdivision regulation, and the same number (although not the same states) exempt them from zoning regulations. Agricultural fills, dikes, fences and buildings also may block floodways and are subject to flood damage; and they can be hazards should an earthquake or tornado occur.

The subdivision of large lots, often over 2-1/2 acres, is subject to regulation in only 29 states. If large lots are exempt, fewer regulatory measures can be applied to sensitive areas.

Non-conforming land uses, defined by the ASPO Model Zoning Ordinance [1966] as lots, structures, or uses lawful before the zoning ordinance was passed but which would be prohibited or restricted under the ordinance, are exempt from zoning regulations in 38 states. Such uses can pose particular hazards in an extreme natural event because the uses are generally unspecified; they tend to be older, unharmonious uses conflicting in intensity and scale with permitted uses in the zoning district. They may exist essentially unregulated until a natural disaster removes them, but in the meantime they affect development patterns and influence risk levels in surrounding areas.

Although exemptions of these uses from zoning and subdivision controls may be supportive of equity, in avoiding the imposition of hardship on farmers and marginal business, and although they may mitigate certain practical difficulties in land use management by allowing greater flexibility, they do reduce the effectiveness of natural hazard mitigation regulations.

Other sensitive uses regulated by some states include, first, inland wetlands. Twenty-two states either have established uniform permit procedures for these areas, or uniform regulations. All eligible states (a total of 30) are participating in the federally-funded coastal zone management program authorized by the Coastal Zone Management Act of 1972. Second, 34 states have the authority to determine the siting of power plants and related facilities. This is an important land use tool particularly with respect to earthquake mitigation. And third, 13 states have established regulations for the identification and designation of areas of critical state concern, such as environmentally fragile areas.

In addition to the above policies, another important land use regulatory measure which can affect natural hazard mitigation is the requirement of permits for certain types of development. Five states currently have such broad legislation. Similarly, 24 states have "coordinated incremental planning," or a state-established mechanism to coordinate state land use problems. And nine states require their local governments, not merely authorize them, to establish a mechanism for land use planning through zoning, a comprehensive plan, and a planning commission.

Related to the direct regulation of land use are the financial policies which support certain land use configurations. For example, the continuing transfer of agricultural land to suburban land on the outskirts of urban areas, resulting partly from increased assessments of peripheral agricultural land, can have serious consequences for a coordinated and comprehensive planning effort. At this time, 42 states have developed tax measures designed to give property tax relief to owners of agricultural or open space lands. A similar policy could help to regulate lands subject to hazards such as landslides, or along a seismic fault, subject to appropriate development by the property owners.

Kusler and the CEQ report on those states which have authorized the adoption of floodplain regulations by state agencies. They indicate that thirty states have adopted regulations which may offer models for more general hazard mitigation measures. Finally, Kusler discusses those states which have included specific flood hazard regulations in various land use measures. A total of 39 states have zoning enabling legislation, and 34 states have similar language for subdivision control. The most common regulatory measure is the power to

secure "safety from flood."

State Coastal Zone Regulations

In addition to statewide authority for natural hazard mitigation, several states have developed regulations relating specifically to the coastal zones adjoining the oceans and the Great Lakes. These activities have been supported by the Federal Coastal Zone Management Act of 1972.

As noted by Platt [NOAA, 1976] California, Washington, and Rhode Island have pioneered the concept of state coastal zone management. While there are major differences between the three states' coastal zone management programs, several common features may be identified. First relevant planning areas consist of entire shorelines, not simply discrete landforms or problem areas. Second, administration is largely a state function with specific responsibilities delegated to certain local and regional entities in the case of California and Washington. Third, state coastal authority extends inland to embrace activities and physical features associated with the coastline.

According to Platt, these programs may be readily adapted to incorporate new perceptions of natural hazards. For example, the Rhode Island Coastal Management Council denies permits for development on "undeveloped" beach areas and seeks to limit construction on dunes or beaches anywhere in the state. [See Figure 19]

Selected provision of state policies are as follows:

1. Shoreline Zoning

"Shoreline zoning" is practiced in Minnesota, Wisconsin, Michigan, and Maine. Here, local governments must adopt land use regulations for their river and lake shoreline areas or such regulations will be adopted on their behalf by the state. In either case, administration of regulations remains with the local government.

2. State Flood Plan Regulations

New York has adopted mandatory floodplain zoning measures for all communities

	COMPREHENSIVE COASTAL OR LAND USE	SHORELAND ZONING	STATE FLOOD-PLAIN REGULA-TIONS	CRITICAL AREAS	COASTAL WETLANDS	SETBACK OR ENCROACHMENT LINES	BEACH AND SHORE PRESERVATION
Alabama	a						
Alaska							
California	b		x				
Connecticut			x		x	x	
Delaware	c				x		x
Florida	d			x		x	x
Georgia					x		
Hawaii	e	x	x			x	
Illinois							
Indiana							
Louisiana					x		
Maine		x	x	x	x		
Maryland	f		x	x	x		x
Mass.					x		
Michigan		x	x				
Minnesota		x	x	x	x		
Miss					x		
N.H.					x		
New Jersey	g		x		x		
New York			x		x		
N.C.	h		x	x	x		
Ohio							
Oregon	i			x			
Pa.							
R.I.	j				x		
S.C.							
Texas					x		
Virginia					x		x
Washington	k		x		x		
Wisconsin		x	x				

[a]Ala. Coastal Zone Development Act of 1973.

[b]Calif. Coastal Zone Conservation Act of 1972 (Final Plan adopted August, 1976).San Francisco Bay Conservation and Development Commission Act of 1969.

[c]Del. Coastal Zone Act of 1971.

[d]Florida Land and Water Management Act of 1974.

[e]Hawaii State Land Use Zoning Act.

[f]Md. State Land Use Act of 1974

[g]N.J. Coastal Area Facilities Review Act of 1973.

[h]N.C. Coastal Area Management Act of 1974.

[i]Ore. Land Conservation and Development Act of 1973.

[j]R.I. Coastal Management Act of 1971.

[k]Wash. Shoreline Management Act of 1971.

Source: Rutherford Platt, "Legal Aspects of Natural Hazards Regulations in the Coastal Zone," p. B-7 in NOAA [1976]

Figure 19 -State Laws Relating to Coastal Hazard Mitigation

with recognized flood hazard areas. Eleven other coastal states, indicated in Figure 19 , have adopted other forms of state-level floodplain management legislation.

3. Critical Areas Programs

The Model Land Development Code proposed in 1975 by the American Law Institute, suggested that states assume particular responsibility for "critical areas," by physical, cultural, economic or aesthetic criteria. As applied to coastal zone management, the critical areas approach is more restrictive geographically than the techniques described above, according to Platt. Critical areas programs have been adopted by Maine, Minnesota, Maryland, Florida, North Carolina, and Oregon.

4. Coastal Wetland Programs

Several states rely on their coastal wetlands permit program for CZM purposes, according to Platt [NOAA, 1976]. With the recent attention given to the importance of coastal wetlands in the ecological food chain, and the extent of their loss due to development along the Atlantic and Gulf coasts, many states have implemented coastal wetland programs.

5. Mandatory Setbacks

A mandatory setback or "encroachment line" may be legally imposed to restrain all further development of fill within a specified distance of a body of water. In Connecticut, encroachment lines have been established to protect the 100 year floodplain of portions of the Connecticut River and certain other streams.

Great Lakes states are turning to mandatory setbacks as a response to severe erosion occurring due to high lake levels. Michigan is proposing a statewide setback for lakeside development equivalent to thirty years of erosion (the average term of a mortgage). Illinois is considering a 100 year erosion setback, a distance of possibly 200 feet along its "North Shore" bluffs.

6. Development Moratoria in Coastal Areas

Most of the measures described above require extensive research and planning studies as a prerequisite to final implementation, notes Platt. Accordingly, some states have adopted an interim period of control through state legislation to be superseded by a final plan. This has been the case in Washington, California, New York, and Florida.

Building Code Policy and Authority

Traditionally, the enactment and enforcement of building codes has been a local government concern. In his survey of flood-related statutory authority, Kusler found that only 23 states had adopted one building code to be used by all governments, or otherwise regulated building code provisions over the entire state. Twelve of these states specifically authorized flood hazard regulations and four states extended building code authority of municipalities to extra-territorial zones. Field and Rivkin [1970], note that over 15,000 localities issue building permits, and approximately 8000 have their own building code, either based on a national code or developed locally.

Four national model building codes are available, from which states or local governments may choose rather than develop a local code. The four code associations are influential in different parts of the country, although there is some overlap (Figure 20). Field and Rivkin [1975] note:

> "The International Conference of Building Officials (ICBO) claims is in the West, Building Officials and Code Administrators (BOCA) in the Northeast, and Southern Building Codes Congress (SBCC) in the South. In the North Central region, BOCA and ICBO actively compete against each other for city members. American Insurance Association (AIna), creator of the National Building Code, is active in three regions, but has no penetration in the West. AInA, unlike the other three code associations, is not an association of building officials. Established in 1905, AInA created the National Building Code as part of their underwriting procedures for ascertaining risk of insurance losses due to fires. Overall, model codes are most evident in the South and West."

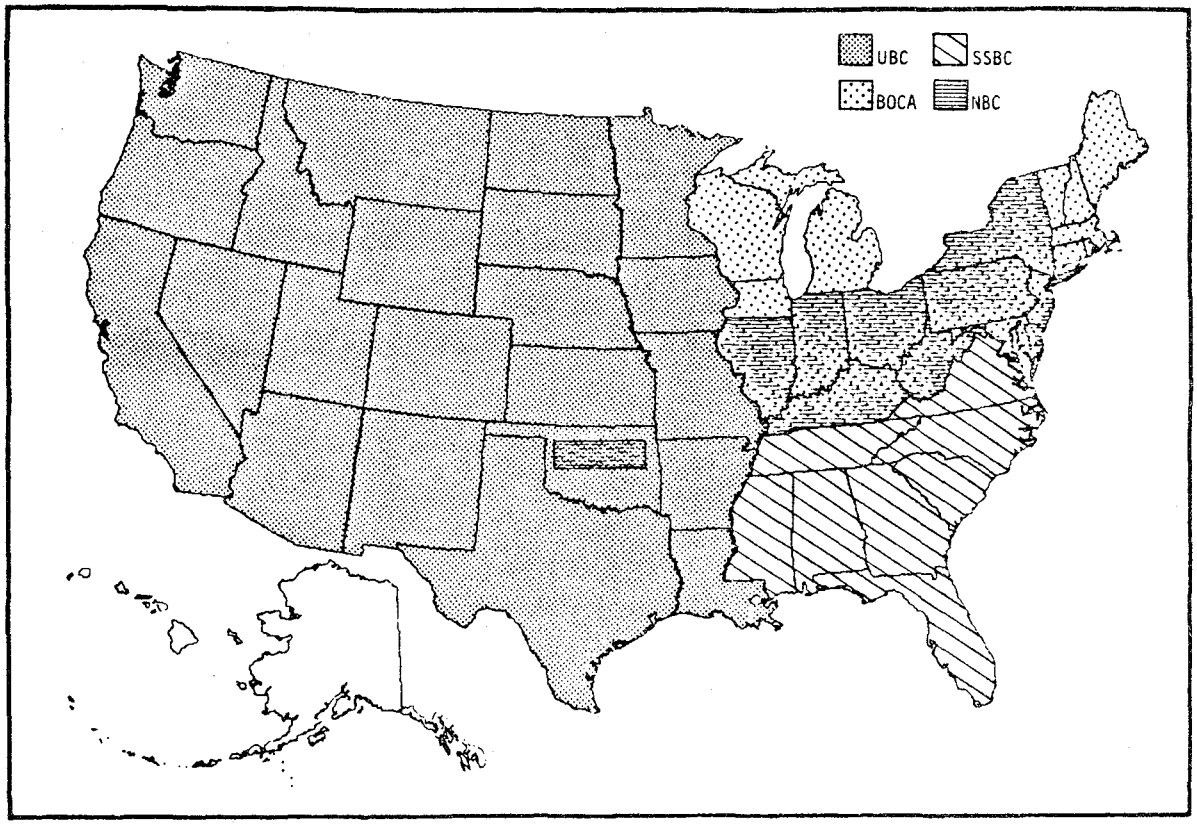


Figure 20 - General Building Code Application by State

In 1970 Field and Ventre [repeated in Field and Rivkin, 1975] surveyed 919 cities in the United States with respect to building codes. At that time 73% of the cities in the survey based their code on one of the four national model codes. State based codes, themselves often based on one of the four model codes, were used by 1.3% of the cities, and locally-drafted codes by 10.8%. Only 2.2% of the cities surveyed (all of them small) reported having no building code. The results of this survey are presented in Table 14. Figure 21 identifies the code utilized by cities over 100,000 population in 1965.

The major hazard-related provisions of the several model codes are as follows:

1. Wind

Although building code policy can be important for the mitigation of several natural hazards, their widest application has been in preventing wind damage, including hurricane winds. The four model codes specify minimum wind loads for design, in terms of minimum wind pressure for various heights above ground level. None of these codes provides specifically for tornadoes.

The methodology and design wind pressures vary among the four model building codes. The BOCA code wind provisions specify a single set of wind pressures that vary with height. The other three codes set forth several sets of wind pressures with height; the set that is applicable for any given location depends upon the expected magnitude of extreme winds for a given level of risk (such as once in 100 years).

The National Building Code has patterned its wind provisions after the recommendations of the American National Standards Institute [ANSI] A58-1-1972 Building Code [1972]. First the basic wind speed must be identified for a municipality; this is accomplished by means of a map which has superimposed upon it isotachs, or contours, of the basic wind speed for a return period of 100 years.

The Southern Standard Building Code (SSBC) of the Southern Building Code Congress also utilizes Thom's 100 year wind speed map to determine the wind speed for a given locality. Wind load pressures are specified in the SSBC code for various values of the basic wind speed. The pressures specified in this code are, however, different than those specified by the NBC.

As with the National Building Code and the Southern Standard Building Code, the Uniform Building Code also utilizes a map; however, the map defines minimum allowable wind pressures at a reference height of 30 feet. From this, the wind pressures for different height zones are determined from a table in the UBC. The 1976 UBC wind provisions have changed little over the years and are essentially the same as found in its 1961 edition [Buoh and Bihr, 1975].

Classification	Number of Cities Reporting	AInA (1)	ICBO (2)	SBCC (3)	BOCA (4)	State (5)	Locally Drafted Code (6)	No Code in Effect (7)
Total all cities	919	12.2%	31.3%	14.9%	15.1%	13.5%	10.8%	2.2%
Population Group								
Over 500,000	12	0.0	33.3	0.0	25.0	0.0	41.7	0.0
250,000-500,000	12	8.3	50.0	25.0	0.0	8.3	8.3	0.0
100,000-250,000	59	3.4	27.1	25.4	15.3	13.6	15.3	0.0
50,000-100,000	111	8.1	39.6	15.3	16.2	16.2	4.5	0.0
25,000-50,000	225	9.3	34.2	11.6	16.9	13.8	13.8	0.4
10,000-25,000	429	16.6	29.8	15.6	13.1	12.6	10.0	2.3
5,000-10,000	61	13.1	16.4	14.8	23.0	16.4	4.9	11.5
Less 5,000	10	0.0	30.0	0.0	10.0	20.0	20.0	20.0
Geographic Region								
Northeast	185	22.2	1.1	0.0	32.4	21.6	17.3	5.4
North Central	249	10.8	22.9	0.4	27.7	14.9	20.5	2.8
South	241	18.3	2.1	56.4	4.1	14.1	3.7	1.2
West	244	0.0	91.8	0.0	0.0	5.3	2.9	0.0
City Type								
Central	149	6.7	29.5	24.8	14.8	12.8	11.4	0.0
Suburban	414	11.1	33.6	7.2	20.0	12.8	14.0	1.2
Independent	340	16.5	28.5	20.6	9.7	13.8	6.5	4.4
Form of Government								
Mayor-Council	240	17.1	15.0	6.7	20.4	19.6	18.8	2.5
Council-Manager	625	10.2	38.9	17.6	12.8	11.5	7.4	1.6
Other[1]	54	13.0	16.7	20.4	18.5	9.3	14.8	7.4

[1] Includes: Cities with commission government, with town meeting, and with representative town meeting.

Source: Field and Rivkin [1975], p. 43

KEY:	MODEL CODE ASSOCIATION	MODEL BUILDING CODE
AInA	American Insurance Ass.	National Building Code (NBC)
ICBO	International Congress of Building Officials	Uniform Building Code (UBC)
SBCC	Southern Building Code Congress	Southern Standard Building Code (SSBC)
BOCA	Building Officials and Code Administrators	Basic Building Code (BOCA)

Table 14 - Building Code Distribution in the United States

CITY	BUILDING CODE
Akron, OH	Local
Alameda, CA	UBC
Albany, NY	Local
Alhambra, CA	UBC
Allentown, PA	BOCA
Amarillo, TX	UBC
Atlanta, GA	Local
Austin, TX	UBC
Baltimore, MD	Local
Baton Rouge, LA	NBC
Bay City, MI	UBC
Beaumont, TX	SSBC
Berkeley, CA	UBC
Binghamton, MY	NBC
Birmingham, AL	SSBC
Boston, MA	Local
Bridgemport, CT	Local
Brockton, MA	Local
Buffalo, NY	Local & State
Burbank, CA	UBC
Cambridge, MA	Local
Camden, NJ	BOCA
Canton, OH	Local
Cedar Rapids, IA	UBC
Charleston, SC	NBC
Charleston, WV	Local
Charlotte, NC	State
Chattonooga, TN	SSBC
Chicago, IL	Local
Cicero, IL	Local
Cincinnati, OH	Local
Clevelan, OH	Local
Columbus, GA	SSBC
Columbus, OH	Local & State
Compton, CA	UBC
Corpus Christiy, TX	SSBC
Dallas, TX	UBC
Dayton, OH	BOCA
Deartur, IL	NBC
Denver, CO	?
Des Moines, IA	Local
Detroit, MI	BOCA
Duluth, MN	?
Durham, NC	State
East Orange, NJ	Local
El Paso, TX	SSBC
Elizabeth, NJ	NBC
Erie, PA	BOCA
Evanston, IL	BOCA
Evansville, IN	Local
Flint, MI	Local
Fort Worth, TX	UBC
Fresno, CA	UBC
Gary, IN	Local
Glendale, CA	UBC
Grand Rapids, MI	BOCA
Greenville, SC	SSBC
Hammond, IN	BOCA
Harrisburg, PA	Local
Hartford, CT	Local
Houston, TX	UBC
Huntington, WV	UBC
Indianapolis, IN	State
Irvington, NJ	NBC
Jacksonville, FL	NBC
Kalamazoo, MI	UBC
Kansas City, MO	Local
Kenosha, WI	State & Local
Knoxville, TN	SSBC
Lakewood, OH	Local
Lawrence, MA	Local
Lexington, KY	NBC
Little Rock, AK	UBC
Long Beach, CA	UBC
Los Angeles, CA	Local
Louisville, CA	NBC
Medord, MA	Local
Memphis, TN	Local
Miami, FL	South Florida
Milwaukee, WI	Local
Minneapolis, MN	UBC
Mobile, AL	SSBC
Montgomery, AL	SSBC
Mt. Vernon, MY	NBC
Nashville, TN	SSBC
New Haven, CT	?
New Orleans, LA	UBC
New York, NY	Local
Newark, NJ	Local
Norfolk, VA	Local
Oakland, CA	UBC
Ogden, UT	UBC
Oklahoma City, OK	NBC
Omaha, NE	?
Peoria, IL	?
Philedelphia, PA	Local
Phoenix, AZ	Local
Pittsburg, PA	Local
Pittsfield, MA	Local
Pontiac, MI	BOCA
Portland, OR	Local
Portsmouth, VA	SSBC
Providence, RI	BOCA
Pueblo, CO	UBC
Racine, WI	Local, ref to NBC & BOCA
Reading, PA	Local
Richmond, CA	UBC
Richmond, VA	Local
Riverside, CA	UBC
Roanoke, VA	NBC
Rochester, NY	Local
Rockford, IL	Local
Sacramento, CA	UBC
St. Louis, MO	BOCA
St. Paul, MN	NBC
Salt Lake City, UT	UBC
Sant Antonio, TX	UBC
San Bernadino, CA	UBC
San Diego, CA	UBC
San Francisco, CA	Local
San Jose, CA	UBC
San Mateo, CA	UBC
Santa Monica, CA	UBC
Schenectady, NY	Local
Scranton, PA	?
Seattle, WA	UBC
Shreveport, LA	SSBC
Somerville, MA	?
South Bend, IN	BOCA
South Gate, CA	UBC
Spokane, WA	UBC
Springfield, MA	Local
Stanford, CT	Local
Stockton, CA	UBC
Syracouse, NY	State
Tacoma, WA	?
Tampa, FL	Local
Toledo, OH	Local
Tulsa, OK	NBC
Utica, NY	Local
Washington, DC	Local
Wichita, KA	UBC
Wichita Falls, TX	Local
Wilmington, DE	BOCA
Winston-Salem, NC	State
Woonsocket, RI	NBC
Worchester, MA	State
Yonkers, NY	Local
York, PA	BOCA

Source: Directory of Safety & Construction Codes USA States & Cities by Karl O. Siemon, Code Publishing Co., N.J., 1965

Figure 21 Code Used in Cities Over 100,000 Population in 1965

The method by which the wind pressures are used to obtain design forces is the same for each building code with the exception of the NBC. The pressures obtained by the BOCA, SSBC, and UBC may be used directly for design while the pressures found by the NBC must be modified by external pressure coefficients before design. For purposes of this study, the UBC has been chosen as the reference code.

To obtain an approximate equivalency in design wind loads among the model codes, the wind pressures specified by the BOCA code must be multiplied by the factors shown in Table 15, to arrive at the same wind forces that would be calculated by the method used by UBC. Tables 16 and 17 are the multiplication factors that need to be applied to the wind pressures of the NBC method to obtain the equivalent design wind forces by the UBC. Tables 18, 19 , and 20 show the multiplication factors to obtain equivalency of the SSBC to the UBC design wind forces.

Of the four model codes, the BOCA code specifies just a single set of wind pressures. These pressures are generally significantly less than that which would be required by any of the three other codes. BOCA does not seem to recognize that higher design pressures may be required. Section 716.0 of the Code does state that "...for building and structures located...in geographical regions subject to higher wind loads than herein specified, the design wind load shall be determined by the prevailing conditions." However, no performance standards or guidance are provided as to what the wind loads should be or what regions may be subject to higher wind loads.

The UBC, although allowing for geographical variation in the minimum allowable wind pressures, is based on wind information that was collected through 1951. This suggests that a re-evaluation of the UBC wind requirements may be in order so that more current wind data are included.

In addition to the wind provisions of the four model codes, local communities subject to severe wind levels have adopted building requirements to meet their local needs. For example, the Corpus Christi, Texas, building code specifications for wind standards were developed from their experience with previous hurricanes.

UBC WIND PRESSURE ZONE (psf)						
20	25	30	35	40	45	50
1.25	1.50	1.90	2.10	2.35	2.70	3.00

Table 15 Multiplication Factors to BOCA Wind Pressures for Approximate Equivalency to UBC Design Wind Loads for All Heights

NBC BASIC WIND SPEED (mph)	UBC WIND PRESSURE ZONE (psf)						
	20	25	30	35	40	45	50
50	1.90	2.20	2.80	3.00	3.50	3.90	4.40
60	1.40	1.60	2.00	2.20	2.50	2.90	3.30
70	1.00	1.15	1.44	1.60	1.80	2.05	2.35
80	0.75	0.85	1.07	1.15	1.35	1.50	1.70
90	0.55	0.65	0.85	0.90	1.05	1.20	1.30
100	0.45	0.52	0.65	0.72	0.85	0.95	1.05
110	0.40	0.45	0.55	0.60	0.70	0.77	0.85
120	0.30	0.36	0.45	0.50	0.57	0.65	0.72
130	0.26	0.30	0.36	0.42	0.47	0.55	0.60

Table 16 Multiplication Factors to NBC Wind Pressures for Approximate Equivalency to UBC Design Wind Loads for Heights Less than 100 Feet

NBC BASIC WIND SPEED (mph)	UBC WIND PRESSURE ZONE (psf)						
	20	25	30	35	40	45	50
50	1.60	2.10	2.50	3.00	3.30	3.70	4.00
60	1.20	1.60	1.90	2.20	2.40	2.80	3.00
70	0.90	1.10	1.30	1.50	1.70	1.90	2.10
80	0.65	0.85	1.00	1.10	1.30	1.45	1.60
90	0.55	0.65	0.80	0.90	1.00	1.15	1.25
100	0.40	0.50	0.65	0.70	0.80	0.90	1.00
110	0.35	0.43	0.50	0.60	0.65	0.75	0.80
120	0.30	0.35	0.42	0.50	0.57	0.65	0.70
130	0.25	0.30	0.35	0.40	0.47	0.55	0.60

Table 17 Multiplication Factor to NBC Wind Pressures for Approximate Equivalency to UBC Design Wind Loads for Heights Greater than 100 Feet

SSBC BASIC WIND SPEED (mph)	UBC WIND PRESSURE ZONE (psf)						
	20	25	30	35	40	45	50
70	1.25	1.45	1.80	2.00	2.30	2.60	2.90
80	0.95	1.12	1.40	1.55	1.75	2.00	2.25
90	0.75	0.90	1.13	1.25	1.42	1.60	1.80
100	0.60	0.72	0.90	0.98	1.15	1.30	1.45
110	0.50	0.60	0.75	0.82	0.95	1.07	1.20
120	0.43	0.50	0.62	0.68	0.78	0.90	1.00
130	0.36	0.42	0.53	0.58	0.67	0.76	0.85

Table 18 Multiplication Factors to SSBC Wind Pressures for Approximate Equivalency to UBC Design Wind Loads for Heights Less than 100 Feet

SSBC BASIC WIND SPEED (mph)	UBC WIND PRESSURE ZONE (psf)						
	20	25	30	35	40	45	50
70	1.10	1.40	1.70	2.00	2.20	2.50	2.70
80	0.85	1.10	1.30	1.50	1.65	1.95	2.10
90	0.67	0.85	1.00	1.20	1.30	1.50	1.65
100	0.55	0.70	0.80	0.95	1.08	1.25	1.35
110	0.45	0.57	0.68	0.80	0.87	1.00	1.10
120	0.38	0.47	0.56	0.67	0.74	0.85	0.95
130	0.32	0.40	0.50	0.57	0.63	0.73	0.80

Table 19 Multiplication Factors to SSBC Wind Pressures for Approximate Equivalency to UBC Design Wind Loads for Heights Between 100 and 500 Feet

SSBC BASIC WIND SPEED (mph)	UBC WIND PRESSURE ZONE (psf)						
	20	25	30	35	40	45	50
70	1.00	1.25	1.45	1.70	1.90	2.20	2.40
80	0.75	0.95	1.10	1.30	1.45	1.65	1.80
90	0.57	0.75	0.87	1.00	1.15	1.30	1.45
100	0.47	0.60	0.70	0.85	0.95	1.05	1.15
110	0.38	0.50	0.60	0.70	0.75	0.87	0.96
120	0.33	0.42	0.50	0.57	0.65	0.75	0.82
130	0.28	0.36	0.42	0.48	0.55	0.62	0.70

Table 20 Multiplication Factors to SSBC Wind Pressures for Approximate Equivalency to UBC Design Wind Loads for Heights Greater than 500 Feet

The Texas Coastal and Marine Council [1976; 1977] and Lesso [1976] analyzed the natural hazard threat along the Texas Gulf coast and established procedures for determining the degree of exposure to "reasonable probable" hurricane conditions. The council also developed a model minimum building standard designed to reduce hurricane damage if implemented as an adjunct to a standard building code.

2. Earthquake

The repeated occurrences of earthquakes have prompted governments in earthquake-prone areas to incorporate lateral-force criteria in building regulations. According to Slosson and Krohn [1977], after the 1933 Long Beach earthquake the Uniform Building Code was amended in 1939 to include earthquake-resistant design requirements. In addition, the 1933 Long Beach earthquake led to the passage by the California legislature of the School House Safety Act (the Field Act) and the Riley Act.

The Field Act required that school buildings be designed to sufficiently withstand earthquakes so that no harm would come to the occupants. Steinbrugge et al., [1978] state that:

> "The Act's principal provisions require that all construction plans be prepared by qualified persons and that the designs be checked by an independent State agency. The independent review is generally considered the most important part of the Field Act, aimed at catching design errors or omissions, or other inadequacies that might not provide adequate earthquake resistance, before construction contracts are let..
>
> Another important aspect of the Act requires construction to be continuously inspected by a qualified person retained by the school board to see that all of the requirements of the plans are carried out. Moreover, all parties, including the architect, engineer, inspector, and contractor, must submit verified reports stating that the approved plans and specifications were complied with in construction.
>
> Knowledgeable observers consider the Field Act eminently successful in assuring reasonable compliance with acceptable levels of earthquake resistance. Almost all Field Act schools have performed well in all earthquakes since the law's passage. While some experts anticipate that some Field Act buildings will be severely damaged in future great earthquakes, there is agreement that injury or life loss will, nevertheless, be greatly reduced because of the Act's requirements."

The Riley Act extended the requirements for earthquake-resistant design to commercial and industrial buildings.

Following the 1971 San Fernando earthquake in California, California's Hospital Act of 1972 was drafted using the Field Act as a guide. The law requires that design work for new hospitals, or substantial additions to or alterations of existing hospitals, be done by qualified specialists. The design must be thoroughly reviewed for safety by the Office of the State Architect.

The 1971 earthquake also precipitated amendments to the City of Los Angeles Building Code for residential structures requiring revisions in the design and construction of diaphragm sheathing, veneer ties, framing, reinforcing of concrete in masonry chimneys, anchorage of water heaters, and regulations related to cutting and notching of walls and studs. It is anticipated that these changes will greatly improve the safety and stability of residential structures with a cost increase of less than 1%.

The City of Los Angeles also has recently enacted code changes for multi-story structures. These changes require site analysis and dynamic analysis with safety requirements for all additions to a structure.

3. Expansive Soil

Of the four model building codes, only the Uniform Building Code specifically mentions expansive soils. Section 2904 specifies a standard test to determine a soil expansion index. In areas with expansive soil, the code only specifies that there shall be a "special design consideration."

4. Landslide

Many landslides are man-induced and result either from the lack of adequate slope grading codes or from non-enforcement of such codes. In Contra Costa County, California, approximately 80% of the landslides are man-related [Nilsen and Turner, 1975].

The effectiveness of adequate grading codes as a deterrent against man-induced landslides is exemplified in the City of Los Angeles. In that community property losses and deaths resulting from landslides and mudflows during the 1950's and 1960's prompted the enactment of local codes and land use regulations to deal with this problem. The heavy rains of January 1952 caused approximately $7.5 million damage within the City of Los Angeles. During the heavy rains of 1952 and 1955, loss or near loss of approximately 150 homes was induced by the Portuguese Bend landslide in Palos Verdes Hills, Los Angeles County. Damages sustained at Portuguese Bend, as well as in other areas of Los Angeles, brought about the first grading codes in 1952.

The grading codes were subsequently updated and improved by the City of Los Angeles one year after the heavy rains in 1962 which caused flood, landslides, and mudflows. This final code change in 1963 greatly reduced the loss or risk factor from man-induced landslides.

The new grading codes were given a test by the severe rains of 1969. An analysis of data collected by the Department of Building and Safety of the City of Los Angeles after the 1969 storm strongly suggests that landslide damage can be essentially eliminated by the proper use of scientific and engineering analysis of building sites in conjunction with realistic codes properly enforced. Statistics on damage to hillside homes from 50-year storms show the value of this approach. (Table 21).

Construction dates and, legal requirements	Number of homes built on hillside sites	Damaged homes Number	Damaged homes Percent of total (%)	Total damage	Average Cost prorated for total number of homes
Pre – 1952 No legal requirement for soils engineering or engineering geology studies	10,000	1040	10	$3,300,000	$300
1952 – 1963 Soils engineering studies required. Minimum engineering geology studies.	27,000	350	1.3	$2,767,000	$100
Post – 1963 Extensive engineering geology and soils engineering studies required	11,000	17	0.15	$ 80,000	$ 7

Data from City of Los Angeles Department of Building and Safety, 1969

Table 21 Landslide and Flood Damage to Hillside Homes During January and February 1969 (50-Year Storm Event). Los Angeles County, CA

Conclusions

Project constraints prevented the study team from independently acquiring detailed data concerning organizational operations, budgetary and expenditure levels, and internal federal, state, and local governmental plans concerning the management of natural hazards. For many of these details we have been dependent on previously published documents and sources of information which are readily available to the professional and lay public. Nonetheless, the following conclusions seem justified on the basis of the evidence at hand:

1. The U.S. Congress already has authorized the Executive Branch to design and implement policies and programs which could provide most of the needed ingredients to a comprehensive, well-integrated, balanced, and rational national-level natural hazards management program.

The disaster relief act of 1974 delivered to the Executive Branch the principal legislative authorizations necessary to the design and partial implementation of a comprehensive, well-integrated, balanced, and rational national-level natural hazards management program.

The act defines "major disaster" as meaning "any hurricane, tornado, storm, flood, high-water, wind-driven water, tidal wave, tsunami, earthquake, volcanic eruption, landslide, mudslide, snow storm, drought, fire, explosion, or other catastrophe in any part in the United States..." The act authorized the president [Section 201 (A)] to establish "a program of disaster preparedness," utilizing "services of all appropriate agencies," such program to include "plans for mitigation, warning, emergency operations, rehabilitation, and recovery" as well as plans for "training...annual review of programs...coordination of federal, state, and local preparedness programs...application of science and technology..research." The president was required by the act to "provide technical assistance to the states in developing comprehensive plans and practicable programs for preparation against disasters, including hazard reduction, avoidance, and mitigation...[Added]. The act further required the president to "conduct annual reviews of the activities of federal agencies and state and local governments providing disaster preparedness and assistance, in order to insure maximum coordination and effectiveness of such programs and...from time to time report thereon to the Congress." [Section

Section 406 of the act requires that, as a "condition of any loan or grant made under the provisions of this act, the state or local government shall agree that the natural hazards in the areas in which the proceeds of the grants or loans are to be used shall be evaluated and appropriate action shall be taken to mitigate such hazards, including safe land-use and construction practices in accordance with standards prescribed or approved by the President after adequate consultation with the appropriate elected officials of general purpose local governments, and the State shall furnish such evidence of compliance with the section as may be required by regulation." Section 201 (C) of the act states that presidentially authorized planning grants to the states shall be used for the "development of plans, programs, and capabilities for disaster preparedness and prevention" and requires states to submit, to the president, plans which shall "set forth a comprehensive and detailed state program for preparation against and assistance following emergencies and major disasters." The president is authorized by Section 601 of the act to "prescribe such rules and regulations as may be necessary and proper to carry out the provisions of this act" and further authorizes the president to "exercise any power or authority conferred on him by any section of this act either directly or through such federal agency or agencies as he may designate."

Thus, the Disaster Relief Act of 1974 provided the executive branch with several specific requirements which it was to meet and further authorized and encouraged action by executive agencies to develop plans for mitigating of the risks associated with exposures to potential disastrous natural hazards, including all of those examined in this study, with the single exception of expansive soils. Interestingly, the United States Water Resource Council Report on a "Unified National Program for Floodplain Management" was submitted to the president in response to Section 1302 (C) of the National Flood Insurance Act of 1968 (PL 90-448) and does not indicate that the proposals in any way relate to the congressional charge upon the president under the terms of the Disaster Relief Act of 1974. Beyond the general authorities contained in the Disaster Relief Act of 1974 are, of course, the specific mandates and authorizations contained in the National Flood Insurance Act of 1969 (PL 90-448) the Flood Disaster Protection Act of 1973 (PL 93-234) the National Dam Inspection Program (PL 92-367), the Coastal Zone Management Act of 1972 (PL 92-583), and the Earthquake Hazards Reduction Act of 1977 (PL 95-124). Statutory authorizations

which underpin the programs of the National Oceanic and Atmospheric Administration, the National Science Foundation, the U.S. Soil Conservation Service, the U.S. Corps of Engineers, and other agencies also buttress the existing legal capacities for hazard related program planning and development operations within the federal establishment. Also, of course, the specific authorizations contained in the Environmental Education Act and other similar statutes provide a basis for extensive implementation of technology transfer and attention-focusing policies in respect to natural hazards management.

2. Both past and current federal natural hazard management policies involve substantial and increasing externalization of the costs produced by natural hazard risktakers.

By June 1975, the multi-decade cost of flood control-projects completed under the supervision of the U.S. Corps of Engineers totaled $10.2 billion (in non-constant dollars). The overwhelming fraction of these costs were incurred between 1936 and 1975. Direct federal expenditures for disaster assistance totaled more than $4 billion between 1953 and 1973 [See Table 17] and from $158 to $173 million per year are currently being expended from tax revenues to subsidize flood insurance programs [See Table 16]. Of course, additional substantial sums are being expended for the annual operation and maintenance of existing area flood protection facilities, for technology development and transfer operations, for administration of disaster relief and other hazard-related programs, and for other similar purposes. The evidence seems to be that annual expenditures for this mix of program purposes are increasing and will continue to increase for several decades to come. Although owners and renters of property within natural hazard zones clearly experience, and will continue to experience, the major fraction of losses sustained as a result of their exposures, it is clear that non-risktakers residing outside these zones also are bearing a significant fraction of the cost of the risk-taking.

As noted above, project constraints prevented a detailed study of the present and probable future magnitude of the externalization of costs that result from

natural hazard risk-taking, but the subject clearly is one deserving of future detailed study.

3. In comparison with national annual expected losses from natural hazard exposures, comparatively small sums currently are being expended by the national government for technology development, technology transfer, and public attention-focusing purposes.

Both the cost associated with natural hazard exposures and the costs associated with efforts to mitigate those hazards are sufficiently large to warrant the cost-effective creation of a national data base adequate to the demands of rational and compassionate decision-making by local, state, and federal policy makers as well as informed policy implementing activities by professionals and administrators in both the public and private sector. Weighed against these costs, federal expenditures for research, technology transfer, and attention-focusing purposes apparently have been rather small. Thus, White & Haas (1975) have observed that "natural hazards research in our nation is spotty, largely uncoordinated, and concentrated in physical and technological fields." Although the Earthquake Hazards Reduction Act stimulates needed research in respect to that hazard, it is not at all clear that research targeted on other areas of knowledge deficiency of equal or greater importance has been appropriately funded.

Little documentation is required to assert that large technical assistance requirements are faced by understaffed and only marginally professional building regulation and planning agencies at local levels and even by the larger state level or regional planning staffs. Fully adequate and completely documented damage and damage reduction algorithms have yet to be developed for most of the major hazards, and hazard zone identification criteria having high predictive quality are all too sparce. Significant sources of non-catastrophic loss, such as expansive soils, have yet to be addressed through the kind of empirically sound and policy useful research that the magnitude of the annual losses would suggest to be warranted. The marginal cost-benefit relationship associated with incremental upward or downward shifts in model building code requirements have only been inadequately addressed. All too many hazard planning and policy influencing documents generated at the federal level or funded by federal agencies are essentially "qualitative" in their approach to

assessments of hazard risks and program payoffs, suggesting the sad state of the data base in this field.

4. There are numerous federal points of leverage which may be employed to support future action-forcing policies at the federal level in respect to the management of natural hazards.

Without considering their political feasibility, there are numerous statutes and federally financed programs which could be utilized to support the future adoption of action-forcing policies, and programs by the federal government. Adoption of appropriate hazard mitigation laws, regulations, and plans by state and local units of government can be made a condition for award of federal disaster relief funds, federal flood insurance subsidies, subsidies for hospitals, and other health care facilities enumerated in the National Health Planning and Resources Development Act (PL 93-641), and could further be made a condition for award of federally-supported or guaranteed mortgages under the programs administered by such agencies as the Veterans Administration, the Farmers Home Administration, and the Federal Housing Administration. It is more than conceivable that such disparate action-forcing policy could focus on land use planning and zoning, other forms of hazard zone avoidance, building codes, notifications of hazard exposures to buyers at time of transfer of property title, etc. (See discussion of legal constraints in Petak, et al.

5. State and local action to promote the avoidance of development in natural hazard zones, to reduce the vulnerability of persons and property within such zones, and to otherwise mitigate the risks associated with natural hazard exposures have been spotty, of widely varying quality, and inconsistent with the dimensions of natural hazard exposure losses.

VIII

PUBLIC POLICY ANALYSIS
THE POLICY OPTIONS AND THE POLICY PLAN

The Policy Options

In theory, public policy-makers at all levels of government currently face at least three major policy options in respect to the management of natural hazards: (1) adopt no new legislative policies or major administrative policies but continue to implement present federal, state, and local policies; (2) adopt no new public regulatory policies at this time and make no major changes in public distributive policies, but concentrate instead on improving the implementation of existing policies and programs through a focus on natural hazard-related system management, system optimization, attention-focusing, technology development, and technology transfer policies, programs, and operations; (3) initiate proposals for major changes in current public regulatory and distributive policies in the field of natural hazards management.

Option 1: "Do Nothing!"
Continue Current Practices and Policies as They Are

This option appears to be unacceptable for the following reasons:

1. Continued implementation of already-enacted policies in accordance with past administrative and organizational approaches would be inconsistent with current demands being voiced by critical actors within the public policy system and by outside parties. [See the President's Message to Congress, May 23, 1977].

2. A mere continuation of existing policies and administrative-organizational approaches could result in the escalation of total annual expected economic losses from natural hazard exposures in the year 2000 to a level of approximately $17.8 billion. Also, annual expected deaths from natural hazard exposures could increase to a level of 1,790 in that year; and such exposures could yield the loss of approximately 172,000 housing units, and could produce

168,300 person-years of homelessness, and more than 2,000,000 person-years of unemployment in that year.

3. The confusion and uncertainty associated with past and current efforts to implement federal policies would continue, and much imbalance would continue to be exhibited in the distribution of federal resources to technology development, technology transfer, and mitigation activities associated with the several natural hazards.

4. The rate at which natural hazard exposure costs are transferred to the general body of non-risktaking taxpayers would continue to increase in magnitude, leading to mounting, and perhaps, imprudent pressures to drastically reduce the magnitude of the federal hazard mitigation effort. Alternatively, the occurrence of a major catastrophe as a result of a high magnitude earthquake or hurricane could stimulate imprudent legislative responses not consistent with the larger needs of the nation and the objective requirements of natural hazard mitigation efforts.

5. "Doing nothing" would be inconsistent with the announced goals of the current administration. Thus, a reorganization of the federal disaster management program has been recommended and is being implemented by the President in the form of Reorganization Plan No. 3 of 1978. In submitting the plan, the President suggested that "by consolidating emergency preparedness, mitigation, and response activities [the plan]...cuts duplicative administrative costs and strengthens our ability to deal effectively with emergencies." The plan establishes the Federal Emergency Management Agency and transfers to that agency the National Fire Prevention and Control Administration and the Federal Insurance Administration, as well as all authorities and functions vested in the President or other federal agencies under the terms of the Disaster Relief Acts of 1970 and 1974, the legislation and orders establishing the Civil Preparedness Agency and the Federal Preparedness Agency in the General Services Administration. The proposed reorganization assigns to the new agency the oversight responsibilities for the earthquake hazards reduction program being implemented under the terms of PL 95-124 and vests the agency with responsibility for coordination of federal activities

relating to dam safety, natural and nuclear disaster warning systems, assistance to disaster-struck communities, and the development of readiness plans for severe weather-related emergencies including floods, hurricanes, and tornadoes.

The President also announced in the reorganization plan his intention to establish, by executive order, an Emergency Management Committee to be chaired by the new agency director and to consist of the assistants to the President for National Security, Domestic Affairs and Policy, and Intergovernmental Relations, as well as the Director of the Office of Management and Budget. Significantly, the President noted in the proposal his commitment to the view that federal hazard-mitigation activities should be conducted under an organizational structure that permits "more rational decisions on the relative costs and benefits of alternative approaches to disasters." He noted his view that "the focal point of all federal hazards and mitigation activity . . . (will be concentrated in) the Federal Emergency Management Agency."

Thus, it seems clear that a continuation of past policies, approaches, and administrative methods in the field of natural hazards management is unlikely.

Option 2: Initiate "Dramatic New" Initiatives and Changes in Current Policy

If a "do nothing" policy is currently infeasible, so also is one that involves immediate and dramatic changes in current basic regulatory, distributive, and action-forcing policy. The current political and social climate of the nation appears to be such that dramatic new federally initiated approaches to natural hazards management problems would not receive appropriate support by broadly based political constituencies nor by important policy-makers at any level of government. Convincing evidence suggests that community-level opinion leaders and policy-makers do not currently assign a very high priority to natural hazards management activities and that their understanding of the dimensions of natural hazards threats to their communities is far too limited. When this fact is conjoined with the economy-in-government campaigns that are sweeping the nation, with the fact that a sufficiently precise and broad-based

pool of data is not yet available to assist rational and comprehensive natural hazards decision-making at all levels of government, and with the current wave of professional and public concern over the burdens produced by governmental regulatory programs, the overall infeasibility of this policy option seems clear. However, this conclusion is not meant to imply that it would be imprudent in the present to establish the general outlines of possible future major changes in natural hazards management policies and programs. Indeed, near-future activities might well be directed to the development of such outlines and to the establishment of the base of policy-maker understanding and support which is a necessary condition for the adoption and implementation of any substantial new proposals.

Option 3: Concentrate Current Activities on a "Fine Tuning" of the Current System

Given the above observations, it would appear that the most feasible option for the present is to concentrate on design and implementation of changes in system management, system optimization, attention-focusing, technology development, and technology transfer policies and operations to the end that a more effective, efficient, balanced, publicly supported, and internally consistent approach to natural hazard problems may be mounted by all levels of government.

The Policy Plan

If our list of "candidate public problems" is accepted by policy-makers, and if the option of "fine tuning" our hazards management system is accepted by those same policy-makers, then the following policy plan is one which may be utilized to develop and evaluate specific policy recommendations.

As the term is used here, a policy plan is a set of goals which describe the end states which are to be achieved through implementation of one or more specific policy proposals. Seven (7) goals comprise the suggested policy plan:

1. Future involuntary exposures to natural hazards should be reduced to an effective level of zero.

One of the oldest and least controversial functions of any government is to protect its citizens from those threats to their health, longevity, safety, and general welfare that are of such a nature that the individual citizen can only imperfectly take action to protect himself or herself. Involuntary natural hazard risk-taking borne out of the ignorance of the risktaker or the inability of the risktaker to adopt a risk-avoidance strategy, or out of the deliberate withholding of hazard exposure and risk-taking information from the parties who are or might be exposed to the hazard, or out of the organizational and technical disabilities of specific community governments are situations that clearly qualify as targets for governmental activity under this traditional role and responsibility of federal and state governments.

2. Future possible increases in the risk of life loss from natural hazard exposures should be avoided.

On the face of it, this goal is one to which most parties would readily assent. It should be given high priority, but the substantial political and economic questions involved in selection of means for its implementation should be frankly acknowledged. If a real commitment is made to the accomplishment of this goal, then a new level of concern should be given to use of avoidance and other preventive strategies for dealing with life-loss problems.

3. Current and future levels of natural hazard costs to non-risk-taking taxpayers should be substantially reduced.

4. Substantial reductions should be made in the level of the projected increase in annual expected losses that are expected to arise from natural hazard exposures in the year 2000.

The projected 1970 to 2000 increase in annual expected natural hazard losses is in excess of the level that was actually tallied in 1970. However important the current level of loss may be, wisdom suggests the importance of a new and

higher level of concern for the projected increases in the sizes of the populations at risk of such exposure.

5. Expanded opportunities should be provided to populations currently at risk of exposure to hazardous natural events to reduce the current level of risk associated with such exposures; but knowledgeably, economically, and in full consideration of relevant costs and benefits.

Accomplishment of this goal is the target of numerous federal, state, and local action programs, including those related to construction of flood control works, disaster relief, disaster warning systems, earthquake prediction, and the strengthening or modification of existing buildings. This goal is worded, however, so as to give clear acknowledgment to the fact that numerous trade-offs are necessary in the processes of decision-making targeted on reduction of the risks incurred by current populations exposed to the conditions within major natural hazard zones. As worded, the goal implies that there may be no single "right" level of risk reduction nor any single "most feasible" strategy to be applied to achieve that risk level.

6. The Federal Government should expand the capacity and readiness of local, state, and federal governmental entities to curb the present and future risks associated with natural hazard exposures.

7. Government should expand the capacity and readiness of individual citizens, groups of citizens, and non-governmental organizations and associations to knowledgeably participate in decision-making activities targeted on determination of the levels of risks and types of mitigation appropriate to deal with natural hazard exposures.

IX

RECOMMENDATIONS FOR PUBLIC POLICY ACTIONS

Introduction

The following set of recommendations for action by federal, state and local policy-makers are targeted on solution of the candidate public problems identified above, are oriented around the option of fine-tuning our existing natural hazards management system, and are intended to implement the policy plan presented in the preceding section.

Recommendations for Federal Action

Recommendation 1. Under the terms of the Disaster Relief Act of 1974 (PL 93-288, Sections 201, 302, 316, 406, and 601) appropriate executive orders and/or administrative regulations should be issued to require initiation of the following activities by federal agencies:

(a) An integrated, centrally coordinated, appropriately budgeted, and appropriately phased program of hazards zone mapping and classification should be designed and implemented. The program should be undertaken as a joint venture of the several federal agencies responsible for this function under the terms of the Disaster Relief Act of 1974, the Earthquake Hazards Reduction Act, and the various statutes concerned with flood insurance and with the mitigation of flood hazards in coastal and riverine flood plains.

Rationally conceived hazard management activities are dependent on precise understandings of the metes and bounds of the geographic areas within which specified hazard occurrences of particular intensities and frequencies may be expected. Virtually all groups and researchers who have examined the subject of natural hazard exposures have recommended an expanded, more timely, more comprehensively conceived program of hazard zone mapping on the part of the federal government. Such activities, we believe, should go

substantially beyond the mere mapping of the turf upon which a particular hazard, such as damage-producing expansive soils, may be expected to occur. In addition, such activities should include a scheme for classifying hazard zones by type, frequency, and expected intensity or magnitude of hazard occurrences. Thus, in respect to such a well-studied phenomenon as riverine or coastal flooding, this recommendation is meant to suggest that riverine and coastal flood plains should be precisely identified as to their metes and bounds; classified as to the frequency with which flooding is expected in the various sections of the plains (flood zones A,B,C,D,E,F); and that each such section should further be classified and coded by height or damage-producing magnitude of the floods expected therein during any flood of a specified frequency. Thus, such a mapping and classification system would require use of a standard and easily understandable coding system which would be consistent across the range of types of hazard zones.

This recommendation is further intended to suggest that: (1) a priority set of areas should be identified for federal designation as hazard zones; (2) such areas should include zones in which both natural and man-made hazards are expected to occur; (3) the classification and coding system utilized for such zones should be in conformance with technical criteria to be developed through consultation with experts from research, mapping, planning, engineering, and user enterprises and fields; (4) the classification system should extend, where appropriate, to such subjects as the soil characteristics of sub-sections of each hazard zone. Some hazard zones would encompass the whole of existing counties or major sections thereof (as in the case of major wind hazards) while other zones would encompass micro areas internal to single communities (as in the case of 10 year flood return zones of specified magnitudes). Of course, any mapping and classification system which is established should be designed so as to permit identification of parcels of land which fall within more than one type of hazard zone. The classification methods developed through an earlier grant by the National Science Foundation to the Southwest Center for Urban Research (Houston, Texas) may well be adaptable to this purpose.

In view of the loss estimates developed in this study, priority in establishment of areas to be subject to the proposed system as well as

priority for completion of the mapping and classification program should be assigned so as to deal, first, with: (1) those hazards which exhibit the largest current and projected losses; (2) those areas which are believed to be within hazard zones which are now highly populated or which are expected to receive a substantial number of migrants between 1980 and 2000; (3) those areas which exhibit the highest annual expected per capita losses of either life or property.

(b) Hazard exposure criteria should be developed for use in association with the hazard zone mapping and classifications system discussed above.

As used here, hazard exposure criteria are defined as predictive or descriptive statements which describe the consequences expected from the exposure of people or property of specified types to specified natural hazards at specified levels of intensity and frequency of occurrence. This definition, therefore, is one which is consistent with the definition of Air Quality Criteria in the Clean Air Act of 1970 as amended.

The recommendation contemplates that such criteria would be quantitative in form; that the use of a variety of expert panels would be necessary to their preparation; and that each criteria statement would be based on empirical evidence or subject to empirical verification. The recommendation further contemplates that the criteria statements would be composed without regard to normative criteria or influences; that they be composed as statements of probable relationships rather than expressions of what "ought to be."

The process of developing such criteria should serve to resolve many of the issues of fact which now surround the field of natural hazards management and should further serve to identify gaps in our present understanding of the relationships between natural hazard exposures and specified sets of consequences.

(c) Hazard Mitigation Criteria should be developed which specify the reductions in damages or other consequences that may be expected from the application of a specified building or other mitigation to a specified set of objects exposed to a natural hazard.

Hazard mitigation criteria are here defined as statements that predict or describe the reductions in damages or other consequences which may be expected from the application of a specified mitigation to a specified area or class of buildings exposed to a given level and frequency of hazard occurrence under a specified set of geophysical conditions. As in the case of hazard exposure criteria, these statements are viewed as being the product of scientific inquiry, technical panel activities, and empirically defensible information, rather than as statements which reflect political, social, or economic biases.

(d) Cost-Feasibility criteria should be developed which express the cost-damage reduction ratios expected from application of a specified hazard mitigation criteria to a set of hazard-exposed objects.

(e) The National Science Foundation should be authorized, funded, and directed to undertake the preparation of such critical literature reviews and the conduct of such research and loss analyses as may be necessary to assure the timely, objective, and effective accomplishment of the above projects in respect to the full range of natural hazards to which the U.S. population is exposed.

Recommendation 2. Hazard zone occupancy and risk analysis studies should be undertaken as the basis for establishment of a national hazard zone model which can be used on a continuing basis to present information concerning the size of the human and building populations which are exposed to the major types of hazards, by frequency and magnitude level.

A comprehensive, balanced, and cost-effective approach to continuing decision-making is necessary to maximize the benefits gained per unit of resources expended on hazards zone research, technology development, and management programs. The proposed national hazards zone model is intended to facilitate the accomplishment of this end by providing, on a near continuous basis, quantitative information concerning the sizes of the populations at risk of exposure to the full range of important natural and man-induced hazards in the numerous hazard zones of the U.S. The recommendation contemplates that:

(a) the model would be capable of revealing the sizes of the populations at risk of exposure in such zones, by type, magnitude, and frequency of hazard occurrence; (b) the level of risk associated with such exposures, expressed in terms of annual expected dollar loss, life loss, injury, and morbidity; (c) the model would be capable of expressing the above in respect to populations and/or land areas which are located within more than one type of hazard zone.

We recommend an early identification and review of current federal efforts and information systems which are relevant to this proposal, a critical review of literature bearing on this subject, and the preparation of a more extended document which would examine the utility, feasibility, and possible cost of such a model.

Recommendation 3. A study should be conducted to determine the capacity of state and local units of government and their professional staffs to engage in the development and implementation of natural hazards management policies and programs, with particular reference to those having implications for building codes, subdivision regulations, housing codes, and land-use planning or zoning standards.

A decade has passed since the report of the National Commission on Urban Problems was developed. With the exception of the study by Field and Rivkin [1975], the recommendations more recently developed by other groups are not generally linked to objective and quantitatively oriented study findings concerning the current administrative, organizational, and staff capacities of local and state governments. The recommendation assumes the need for such a study and assumes that: (a) such a study would be directed at cities, counties and states exhibiting the highest potential for natural hazard losses; (b) the study would include an examination of plans and programs developed under the terms of the Coastal Zone Management Act, the Disaster Relief Act of 1974, and other similar statutes. It further assumes that such studies would focus on explication of user agency perceptions of the quality, thoroughness, utility, availability, and consistency of current federal regulations, guidelines, technical assistance documents, and other similar materials.

Recommendation 4. A comprehensive study should be undertaken to determine the substantive content and applicability to natural hazards management of: (a) the several model building codes; (b) the several "model" or "recommended" state and local hazard-related building, zoning, and subdivision ordinances and state hazards management acts; (c) regulations and standards of federal agencies; (d) state, county, and local building codes, subdivision regulations, housing codes, and planning ordinances in areas most impacted by potential natural hazard problems.

This recommended study would provide the information base necessary for development of agency and area-specific recommendations concerning possible modifications in natural hazard management policies and structures. The recommendation contemplates that exemplary enactments by local, state, and other bodies would be assembled; that objective criteria would be developed for classifying the sum of the regulations examined; and that the output of the study would be useful for a mix of policy-planning, technical assistance, and staff development purposes.

Recommendation 5. Current federally sponsored and/or financed training and technical assistance programs and activities in the field of natural hazards management, and in related fields, should be identified, their respective contents and clientele determined, and their compatibility with current and future needs assessed; and a comprehensive, well integrated program of training and technical assistance in support of natural hazard programs at local and state governments thereafter should be developed.

As used here, the terms "training" and "technical assistance" are meant to include training institutes, symposia, newsletters, manuals of instruction, and other materials and services intended to facilitate the conduct of technically competent activities, operations, and decision-making by personnel of local and state governments.

The recommendation contemplates that activities funded under the terms of the Environmental Education Act, the Intergovernmental Personnel Act, and the statutes relating to hazards management and urban or community development

would be included within the scope of this recommendation. The suggested study should focus, in part, on identification of possible revisions in the guidelines governing these existing activities so as to increase their utility to the field of natural hazards management.

The recommendation further contemplates that training and technical assistance activities should be targeted on such groups as: (1) elected policy-making officials of local and state governments; (2) technical personnel of land-use planning, regional planning, resource development, building regulation, and subdivision control agencies and organizations.

Recommendation 6. A comprehensive, well coordinated and continuing program of public information and education should be conducted so as to acquaint national, state, and local publics and public policy-makers with the essential facts concerning natural hazard exposures, consequences, and alternative mitigation strategies:

It seems clear that responsible and informed future decision-making in the field of natural hazards management will require the active participation of an informed public. Yet, the evidence is overwhelming that even the residents of high hazard areas do not fully comprehend the extent of their risk, the consequences associated with exposures, and the types of adjustments that may be made to mitigate the effects of those exposures. Of course, the design of such a program would require the identification and review of the numerous segmented public information and education efforts in this field that are sponsored by the panoply of federal agencies whose responsibilities impinge in one way or another on the subject of natural hazard exposures.

Some specific possibilities for such a program are as follows:

(a) A "White House" or "National Conference" on Management of Environmental Hazard Zones could be conducted.

When the federal air quality management effort was little more than a loosely coordinated committee effort within the U.S. Public Health Service, Los Angeles County officials requested President Eisenhower to convene a

White House Conference on Air pollution. The resulting series of National Air Pollution Conferences which were conducted by the Department of HEW accomplished several ends: (1) the attention of the national media, influential private associations and organizations, educators and researchers, and policy-makers at all levels of government were drawn to the air pollution problems of the nation; (2) issues and ideas concerning the mitigation of the problems were ventilated before the public eye; (3) major policy alternatives were identified and examined by a national group of interested parties.

Similar benefits might well result from such an effort in respect to the potential problems posed by continued exposure of people and property to the numerous types of hazard zones within this nation.

(b) Conferences, workshops, and symposia might be conducted for community leaders, influentials, and media representatives of high damage-rate states and counties.

(c) Highly readable and objective brochures on each of the study hazards could be prepared for distribution to lay publics in areas exhibiting moderate to heavy annual expected losses from exposures to such hazards.

(d) Objective but highly readable and illustrated feature articles on this subject could be prepared for distribution to community (weekly and semi-weekly) newspapers in moderate to high hazard areas.

(e) A series of documentary films could be prepared for broadcast by the Public Broadcasting System and for use by commercial stations.

(f) Under the auspices of a university or some other institution, a series of objective, empirically-defensible, but highly readable hazard-specific "Public Policy Reports" could be prepared for distribution to state and local public policy-makers representing hazard areas in which cost-feasible mitigations can be put to use.

As suggested by this study, the prime candidate subjects for such a series of reports are: tsunami, landslide, wind hazards, coastal and riverine flooding.

Recommendation 7. In cooperation with elements of the American insurance industry, a comprehensive, well-budgeted study should be undertaken to (a) determine the possible utility of both comprehensive and categorical hazards insurance systems in the mitigation of the consequences associated with natural hazard exposures; (b) identify the present public policies that constrain the development and extension of such insurance services; (c) review, and possibly develop, new data concerning the factors that influence consumer attitudes toward such insurance; (d) and identify the possible functional and dysfunctional consequences associated with legal requirements calling for mandatory purchase of such policies.

In view of the cost-feasibility problems that may be associated with other loss-mitigating strategies in the field of natural hazards management, the potential utility of risk-spreading insurance systems should be determined. Although this subject was not pointedly addressed in the inquiry that resulted in this report, the subject is one whose large importance to natural hazard management programs was suggested by project data outputs. Consideration should be given to a preliminary feasibility study aimed at capturing and assessing existing literature in this field and at identifying information requirements that are perceived to be important by knowledgeable members of the insurance industry, insurance regulating enterprises, and natural hazard management authorities.

Recommendation 8. A comprehensive study should be conducted to identify the past, present, and probable future annual costs of natural hazard exposures which have been, or will be, externalized to non-risktaking parties.

Recommendation 9. Study findings concerning the specific counties in which cost-feasible natural hazard mitigations may be employed should be utilized by those federal agencies which review coastal zone plans and by those federal officers responsible for the conduct of hearings and the drafting of regulations to implement Section 406 of the Disaster Relief Act of 1974.

Coastal zone management programs already have been approved for two states (Washington and Oregon), approval of two others is expected shortly, and nine others currently are at the point of being submitted (CEQ Annual Report, Dec. 1977).

Similarly, the Department of HUD recently has announced its intention to conduct public hearings to determine what provisions to include in the regulations to be issued to implement Section 406 of the Disaster Relief Act of 1974.

Recommendation 10. The federal government should require parties involved in the sale, transfer, renting, or leasing of property to engage in full disclosure of the natural hazard-related risks associated with the property and the hazard zones in which it is located.

This recommendation contemplates ultimate legislation that would require "full disclosure" on the part of those who sell or offer to sell and of those who offer for rent or lease any parcel of developed or undeveloped property within the United States when such property falls within an area that the federal government has determined to be bounded by a federally designated hazard zone. The recommendation contemplates that potential purchasers, renters, and lessees of such property be advised by the seller, lessor, or any agents thereof of the nature and classification of the hazard zone within which the property is located, and that this assertion be verified (in the case of property sales) at time of title transfer by the title insuring agency. Although the adoption of a direct federal legislative requirement of this type may exceed the constitutional authority of the federal government, it would appear that adoption of such legislation by state legislatures could well be "forced" by the federal government through federal insistence that the adoption of such legislation be a necessary pre-condition to the establishment of the eligibility of the state, any portion thereof, or any citizen thereof for any benefits under the terms of the Federal Disaster Relief of 1974; the Federal Flood Insurance Act, as amended; the various federal flood control acts; and those acts that authorize the activities of such agencies as the Federal Housing Administration and the Federal Home Loan Administration.

In respect to regulations issued under the authority of Federal agencies engaged in mortgage transactions, it should be noted that **Executive** Order 11988 (May 24, 1977) now requires that "agencies which guarantee, approve, regulate, or insure any financial transaction which is related to an area located in a flood plain shall, prior to completing action on such transaction, inform any private parties participating in the transaction of the hazards of locating structures in the flood plain." [42 Federal Register 101, May 25, 1977].

Recommendation 11. The federal government should continue to sponsor and fund feasibility studies in respect to area flood protection works, should continue to engage in the design of such works, but should alter past policies so as to permit and require the participation of beneficiary parties in the funding of the capital and operating costs associated with such facilities, and so as to prohibit federal participation in any project in which the required benefit-cost relationships can be demonstrated only under conditions of increased flood plain occupancy.

By and large, past federal policies have involved an all-or-nothing approach to the provision of coastal and riverine flood control facilities to communities and states. If such projects were deemed necessary and qualifying under appropriate policies, then the federal government picked up the lion's share of the bills for the project. The recent study of the U.S. Water Resources Council found that only 11% to 20% of the mean, effective, composite cost of rural and urban flood damage reduction facilities and programs, respectively, is being borne by non-federal entities. [U.S. Water Resources Council, 1975].

This recommendation contemplates an end to these past policies and assumes that not only the beneficiary states would be partners in the financing of future flood control projects, but the further requirement that precise boundaries be drawn by federal authorities to reveal the land areas and property owners who are the real beneficiaries of risk reductions associated with each flood control project, and that all, or a substantial fraction of the capital and operating costs of such facilities, be imposed on such land areas and parties. The intent of this recommendation is both to limit past externalization of flood control costs and to provide an opportunity for

existing hazard-exposed populations to conveniently exercise the option of mitigating their local risks through use of flood control works, but only under conditions where the project beneficiaries internalize a large fraction of the costs associated with such flood control activities. Such an amendment of policy could be linked to further requirements intended to prevent future build-ups in flood plain occupancy to levels which might boost total flood-induced costs as a result of enlarged population exposures to greater-than-project flood magnitudes.

In its major thrust, this recommendation is consistent with the spirit and purpose of the several recommendations and declarations advanced by the United States Water Quality Council [Council, 1973; Council, 1976], the U. S. Congress [P.L. 93-251, Section 80], and the President. In his message to the Congress on May 23, 1977, the President observed that "...it is essential to confine the public works efforts of the water development agencies to projects that can meet such defensible criteria as economic efficiency, safety, environmental protection, and fair distribution of project benefits."

This recommendation contemplates that: (a) the major fraction of the costs associated with construction of area hazard protection works (dams, levees, sea walls, etc.) should be internalized to those who receive the benefits from such expenditures; (b) the construction of such works should be justified in terms of the need to reduce the risks associated with the exposure of existing populations and property to the hazard, and should be so controlled and managed as to prevent unreasonable increases in the sizes of the populations at risk as well as increases in the absolute level of losses resulting from such exposures; (c) the opportunity for current natural hazard risktakers who employ this approach to reduce <u>their</u> levels of risk should be preserved, but in a context in which such risktakers must weigh the costs, benefits, and tradeoffs associated with this approach. The idea that local beneficiaries should share in the costs of federal flood control projects and activities was endorsed by several national groups during the 1975 public hearings conducted by the U.S. Water Resources Council. [The Council, 1975]. During those hearings the following positions were taken concerning these matters by spokespersons for the indicated groups:

American Society of Civil Engineers: "Reimbursement and cost sharing policies should be directed generally to the end that identifiable beneficiaries bear an equitable share of cost commensurate with beneficial effects received in accordance with the project planning objectives."

American Water Resources Association: "The AWRA concurs in general with recommendations for increased non-federal cost sharing. The federal share of financing of water resource programs is often unduly generous, to an extent which results in uneconomic expenditures."

Wildlife Management Institute: "...inadequate cost-sharing policies have promoted unwise development of flood plains and led to over-emphasis on ecologically damaging structural solutions to flood problems."

League of Women Voters Education Fund: "...the League has long supported user charges and the general principle that beneficiaries should share in the cost in proportion to benefits received...many projects receive community support because little community investment is required."

Recommendation 12. All federal highways and all other highways which were constructed and/or are maintained in whole or in part with federal funds should be equipped with signs which indicate the points at which those highways transect major natural hazard zones, including - but not limited to - tsunami innundation areas and 100-year, 50-year, 25-year, and 10-year coastal and riverine flood plains. In areas subject to flooding, such signs should further indicate the flood heights expected at signed points during a flood of 100-year frequency.

The purpose of this recommendation is to stimulate the development of improved public understanding of the location of life and property-threatening natural hazard zones and thereby to both reduce involuntary risk-taking and to increase the use of risk-reducing adjustments by residents in, and users of, such zones. In its major thrust, the recommendation is consistent with the

spirit of Section 3 (c) of Executive Order 1198 (May 24, 1977), which states, in respect to federal property, as follows:

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

Recommendation 13. Building standards enforced by federal lending and mortgage guarantee agencies should be amended so as to require the use of building strengthening mitigations (for wind, flood and earthquake hazards) on new structures in those counties and sub-county areas in which the use of such mitigations has been found to be cost feasible.

It is the intent of this recommendation that federal lending and mortgage guarantee activities be utilized to foster the use of loss-reducing building strengthening and/or floodproofing/elevating mitigations in those areas and under those conditions where the use of such mitigations is both cost-feasible and contributory to the production of net reductions in the annual expected losses from area natural hazard exposures. This requirement should be extended to expansive soils and other hazard mitigations as rapidly as warranted by available evidence.

Recommendation 14. Federal regulations issued under the terms of Section 406 of the Disaster Relief Act of 1974 should be designed to foster the use of the "highest net savings" mitigations identified in Figure 10.

Recommendation 15. Hazard impact and mitigation statements should be required additions to the Environmental Impact Statements currently required in respect to federally conducted or federally financed projects.

As used here, the term "hazard impact and mitigation statement" is intended to mean an objectively prepared statement which: (a) identifies the natural hazard zones or areas in which capital facilities are to be located and/or in which programs are to be conducted; (b) specifies the mitigations which

will be employed to reduce the adverse impacts otherwise associated with exposure of project-related persons and properties to the hazards within the area; (c) identifies the hazard adjustments whose use will be fostered through use of program funds.

It is the intent of this recommendation that such statements be prepared for such critical capital facilities as schools, hospitals, nursing homes, community health centers, and other facilities whose location might well increase the size of the involuntary population at risk of exposure to natural hazards. It is the further intention of this recommendation that such statements be employed to determine the extent to which federally-funded education and other programs have been appropriately adapted to the natural hazard needs of specific areas. Thus, in respect to educational subventions to the states, such statements might well deal with such questions as those relating to the extent to which public school curricula have been designed so as to foster community use of life-saving and injury-avoiding adjustments to such natural hazards as tornadoes, coastal floods, riverine floods, and earthquakes.

Recommendation 16. A comprehensive, federally administered or initiated national program of natural hazards insurance should be designed and implemented.

Should the cost-feasibility findings of this study remain essentially undisturbed after full implementation of Recommendation #1, then widely available, affordable, comprehensive natural hazard insurance would have to be viewed as a leading strategy for reducing the potentially catastrophic personal and familial losses otherwise associated with continuing future exposure of those population subsets which now are at risk of incurring such loss as a result of past locational decisions.

Recommendation 17. The terms of the Federal Disaster Relief Act of 1974 should be altered so as to stimulate and require state and/or local cost sharing in the post-disaster relief and community rehabilitation services now being funded by the federal government under the terms of that act.

Under present conditions, local politicians, state governors, and other actors within the American policy system face unusual pressures and motivations to declare a wide variety of natural occurrences as "disasters" and thereby to qualify the populations impacted by those events for a variety of federal subsidies and services. At state and local levels, it can be argued that there is little present incentive to abridge appropriately the circumstances under which such declarations are made, nor is there much incentive for state and local communities to build actuarially sound funds which can be used to deal with the needs posed by future hazardous occurrences within their jurisdictions. The result of this situation has been an apparently mounting federal cost burden for relief and rehabilitation efforts associated with the occurrence of natural disasters.

Recommendation 18. A National Natural Hazard Management Act should be adopted to replace the existing separate enactments dealing with floods, flood insurance, earthquake hazards, and disaster relief-recovery. Such an act should include providing for the implementation of all the above recommendations and should further require that: (a) states seeking to qualify for comprehensive natural hazard insurance and other benefits related to disaster relief and recovery be required to meet specified conditions; (b) the state-qualifying conditions should include a showing that the state has enacted a natural hazards management act which provides for the specification of intra-state natural hazards management zones, for effective use of federally developed hazard zone mapping and classification information as well as hazard exposure, hazard mitigation, and cost feasibility criteria.

Recommendations for State Action

The following recommendations recognize that: (a) the primary responsibility for the management of natural hazard zones now resides with state and local units of government; (b) much responsible action can be taken by these units through use of information which already is generally available; (c) the long-term efficacy and cost effectiveness of state/local action will be influenced by the extent to which the recommendations for federal actions are implemented.

Recommendation 1. Coastal states exposed to tsunamis should promptly: (a) identify tsunami inundation areas within their borders; (b) provide for appropriate marking of these areas; and (c) prohibit any new residential development within the boundaries of such zones.

The technical mitigations which have been proposed for tsunami in this study are based on the assumptions that: (a) there are no effective building-strengthening mitigations which may be employed to protect residents of non-engineered dwelling units from the threat of injury and life loss posed by this hazard; (b) the primary methods for reducing or preventing future injury and life loss from this hazard are those which involve the application of avoidance, hazard warning, and population evacuation systems. The only structures which should be located in such areas are those which meet three tests: (1) they are economically necessary to such places; (2) they cannot be located in other areas; (3) they are engineered structures.

Recommendation 2. All states abutting the Gulf of Mexico and the Atlantic Ocean should enact legislation and/or take such other action as may be necessary to secure the mapping of coastal flood plains (by frequency and magnitude of expected floods) and the early use of appropriate risk-reducing mitigations within those areas, including: (a) avoidance of all new and replacement construction within the more hazardous of these areas; (b) the avoidance of net new growth in all areas in which there is a moderate or high risk of property and/or life loss; (c) the use of area protection, building strengthening, and building elevation mitigations for those portions of the flood plains in which low to moderate risks are faced, in which the use of such mitigations are cost-feasible, and in which there is some ascendant need for further development and/or for the protection of existing populations and properties.

Recommendation 3. All states should adopt Natural Hazard Management Acts which require the mapping of natural hazards zones within their boundaries and which require the parties involved in the sale, transfer, renting, or leasing of property to engage in full disclosure of the natural hazard-related risks associated with occupancy of structures and places within natural hazard zones.

In respect to the second portion of this recommendation, some states may wish to consider the enactment of amendments to their business and licensing codes so as to also incorporate the recommended requirement in those codes which govern the conditions under which business or professional licenses may be awarded or periodically re-awarded to persons engaged in the development, sale, transfer, rent, or lease of property.

This recommendation also contemplates that state Natural Hazard Management Acts also should require Departments of Public Instruction to assure that public school curricula include instruction which fosters student understanding of the adjustments which are appropriate to minimize the risks of injury and life loss associated with exposure to the major natural hazards which are endemic to the state.

Recommendation 4. All states should adopt legislation which either imposes minimum and maximum building and housing code requirements on all appropriately populated local areas, or which requires state-conducted audits and public reports concerning such enactments and the effectiveness of related local enforcement efforts.

Assuming the contemporary correctness of the findings which were offered elsewhere in this report concerning the quality and effectiveness of locally-enacted building and housing codes, and the enforcement programs related thereto, it seems clear that such codes and enforcement activities may well be of uncertain quality in many areas of the nation and inconsistent with local needs for the mitigation of natural hazard risks.

This recommendation assumes that there are three major options which are open to state governments for dealing with this possible problem: (a) ignore the problem; (b) solve the problem by providing for a state-enacted and enforced system of building, housing, and sub-division codes; (c) take more limited action which preserves local choice over this important subject but which provides maximum assurance that such decisions are based on the current state of related knowledge and are made under conditions where full public participation in the process is assured.

Recommendation 5. All states should adopt or amend state subdivision statutes so as to require that all subdivision applications submitted to any local or state entity must include a hazard impact or mitigation statement, the contents of which must also be provided to all prospective purchasers of such property prior to consummation of title transfer.

This recommendation contemplates that the required "hazard impact and mitigation statements" would conform to the description in the Recommendations for Federal Action. Implementation of this recommendation by state governments would provide an immediate mechanism for dealing with exposure problems that otherwise might arise until that future time when the natural hazard zones of the nation have been fully mapped and appropriately classified. It requires the subdividers of property to appropriately examine the major natural hazard features of all potential subdivision sites and to demonstrate that site and construction practices will conform to appropriate hazard-mitigating criteria. The recommendation stops short of suggesting that any specified set of mitigations should be required for sites of particular types, but does contemplate that the information provided in the "impact and mitigation statement" would prompt appropriate regulatory activity by local and state entities charged with responsibility for reviewing and approving such subdivision applications.

Recommendations for Local Units of Government

The following recommendations are intended for implementation by those local units of government whose location, current population size, or anticipated future growth rates suggest the wisdom and feasibility of local action to mitigate the risks associated with natural hazard exposures. At a minimum, such local units of government are defined as including those located within coastal counties adjacent to major inland lakes, to the two oceans, and to the Gulf of Mexico; those units which are subject to riverine, coastal, and other flood problems; those units which are located in areas at risk of seismic activity; those areas in which a significant fraction of the land area or population is exposed to expansive soils or landslide hazards; those units located in sections of the United States which are particularly vulnerable to wind-induced damage from hurricanes, tornadoes, or other severe wind storms.

Recommendation 1. Each local unit of government should identify the natural hazards to which the human or building populations within its jurisdictions are exposed, the boundaries of the natural hazard zones within which such exposures take place; frequency with which hazardous occurrences of various magnitudes are expected within each such zone; and the type and extent of damage, injury, or life loss which is expected within each such zone.

It is the intention of this recommendation that the governing body of each local unit of government should, after receipt of appropriate technical counsel and the conduct of appropriate public hearings, determine the hazardous natural occurrences which are significant enough to the population of that community to warrant public mitigating actions and/or the drawing of natural hazard zones for each such hazard. In those circumstances where such action is deemed appropriate, boundaries would be fixed for natural hazard zones in which such occurrences as expansive soil activity, riverine or coastal flooding, other flooding, earthquake fault activity, landslides, local winds of high velocity, and other similar occurrences are expected.

A wide variety of data currently is available to support local activities of this sort. Thus, the National Oceanic and Atmospheric Administration (NOAA), the U.S. Geological Survey (USGS), the U.S. Army Corps of Engineers, and the U.S. Soil Conservation Service are now engaged in the identification and mapping of hazardous natural areas, including those susceptible to earthquakes, tsunamis, landslides, volcanic activity, coastal flooding, and riverine flooding. In addition, one or more of these same agencies engage in the preparation and publication of maps and other data concerning local soil characteristics. These may be utilized to assist local jurisdictions in identifying those areas in which landslide or expansive soil activity may be expected.

Recommendation 2. The master land use plans which have been adopted by local units of government should be modified to include an identification of the natural hazard zones for which boundaries have been drawn as a result of the implementation of the above recommendation.

Recommendation 3. Each local unit of government should prepare and adopt, following appropriate review by local, state, and federal agencies, and following the conduct of appropriate public hearings, a local Natural Hazards Management Plan and Program.

As used here, the term "Natural Hazards Management Plan and Program" is intended to mean a document which: (a) specifies the criteria followed in drawing the boundaries of natural hazard zones; (b) identifies the policies which are to be observed in managing the exposure of people and property to hazard occurrences within such areas; (c) identifies the effects which are expected to be achieved through implementation of the plan; and (d) the residual effects which are expected to continue if all elements of the plan are implemented.

It is intended that such a plan should provide specific technical and policy guidelines to all local agencies and private parties who are engaged in the development and implementation of subdivision regulations, land use plans, building codes, housing codes, in other activities related to the warning and evacuation of populations from hazardous areas, or in the extension of post-disaster relief and recovery services to such populations.

Recommendation 4. Local subdivision ordinances should be amended so as to require: (a) hazard impact and mitigation statements to be filed with all subdivision applications by applicant parties; (b) prohibit new subdivisions in high-hazard zones; (c) soils testing, site stabilization, site avoidance, or other site modification activities in specified hazard areas, such as those associated with potential landslide or expansive soils activity.

The suggestion that subdivisions be prohibited in high-hazard areas is meant to provide a means for implementing the study-identified technical mitigation for landslide, and to provide local units of government with the means for avoidance of new construction in such high hazard areas as tsunami inundation zones and the high-frequency/magnitude segments of riverine and coastal floodplains.

Recommendation 6. By local ordinance, provision should be made by local governing boards for the mandatory and periodic review of: (a) the natural and other hazards for which zonal boundaries have been set by the jurisdiction; (b) the accuracy of current boundary lines for such hazard zones; (c) the hazard-mitigating efficacy and cost-feasibility of the jurisdiction's natural hazards management plan or program.

Recommendation 7. Local units of government should review their use of IPA and CETA funds to determine the extent to which those funds now are being appropriately used to meet local natural hazard management requirements.

In many local communities, CETA funds might well be used for such purposes as the removal of particularly vulnerable structures from such high hazard areas as those subject to frequent coastal or riverine flooding. Similarly, CETA personnel could be used to assist low income families in the flood-proofing of their properties.

IPA funds may be used by local jurisdictions to send the technical staff of their planning, building, and other hazards management agencies to short-term training institutes concerned with natural hazard management subjects.

Recommendations for Action by Private Entities

The more rapid and effective amelioration of problems posed by natural hazard exposures may be fostered if appropriate private organizations and associations take action to foster improved public and policy-maker understanding of exposure problems and of the major problem-mitigating opportunities. Illustrative of the possibilities are the following recommendations.

Recommendation 1. The American Association for the Advancement of Science should: (a) appoint a multi-disciplinary Commission on Management of Environmental Hazard Zones; (b) charge the Commission with responsibility for preparation of a report on the subject which is of the scope and quality of the report issued by the AAAS Commission on Air Conservation.

Recommendation 2. An inter-society committee on National Hazard Management Criteria and Research should be sponsored by appropriate national professional societies.

The memberships of a number of professional societies are professionally involved in operations associated with the identification of: (1) natural hazard areas; (b) natural hazard effects; (c) natural hazard mitigations, costs and consequences. Among such societies are: the American Meteorological Society; the American Society of Civil Engineers; the American Institute of Architects; the American Institute of Planners; the American Public Works Association; the National Association of Insurance Commissioners; the International Conference of Building Officials; and others.

A joint committee representing these several societies could profitably be employed to review the need for, and to develop specific recommendations concerning the several proposals in Recommendation No. 1 for federal government Phase 1 activities. Such a committee could continuously concern itself with identification of the types of criteria needed in the field of natural hazards management and with the type and scope of research necessary to the development of such criteria.

The Recommendations and the Problems

The intended problem targets of the several recommendations which were advanced above are depicted in Figure 22.

	INTRINSIC PROBLEMS										INSTRUMENTAL PROBLEMS													
	1. INDIVIDUALS RESIDING IN HAZARD ZONES	2. WHOLE COMMUNITIES AT RISK OF LOSS	3. VISITORS INCUR INVOLUNTARY RISK	4. LOSSES EXCEED ANNUAL MITIGATION COSTS	5. REDUCED PROBABILITY OF MORTGAGE PAYOFF	6. PROBLEMS WILL CONTINUE TO INCREASE IN MAGNITUDE	7. COSTS TRANSFERRED TO NON-RISK-TAKING TAXPAYERS	8. POLICIES INCREASE PROPERTY COST	9. POLICIES THREATEN INDIVIDUAL AND COMMUNITY VALUES	10. IMPAIRED IMPROVEMENTS IN HUMAN LONGEVITY	1. INADEQUATE PROGRESS IN HAZARD ZONE MAPPING	2. INADEQUATE DATA FOR DEVELOPING MITIGATION CRITERIA	3. INADEQUATE DATA TO ESTABLISH COST-LOSS REDUCTION RATIOS FOR MITIGATION	4. INADEQUATE INFORMATION TO SUPPORT MODEL BUILDING CODE REQUIREMENTS	5. LOCAL BUILDING CODES OF UNCERTAIN QUALITY CAN BE INCOMPATIBLE WITH NATURAL HAZARDS MANAGEMENT	6. LIMITED EFFECTIVE LOCAL PLANNING AND IMPLEMENTATION	7. LOW LEVEL OF LOCAL NATURAL HAZARD PERCEPTIONS	8. WEAK CONSTITUENCY FOR NATURAL HAZARD POLICY	9. POLICY FAVORS FINANCIAL ASSISTANCE AND AREA PROTECTION WORKS	10. INADEQUATE COORDINATION OF FEDERAL NATURAL HAZARD PROGRAMS	11. LIMITED OPPORTUNITY TO PURCHASE HAZARD INSURANCE	12. LOW PUBLIC INTEREST IN NATURAL HAZARD INSURANCE WHEN AVAILABLE	13. FEDERAL RESEARCH EXPENDITURES NOT MATCHED WITH ANNUAL EXPECTED LOSSES
RECOMMENDATIONS FOR FEDERAL ACTION																								
PHASE 1: 1. a) Hazards zone mapping and classification	o	o	o	o	o	o			o	o	o	o	o			o	o	o			o		o	o
b) Develop hazard exposure criteria	o	o	o	o	o	o			o	o		o	o			o	o	o			o		o	o
c) Develop hazard mitigation criteria	o	o	o	o	o	o			o	o		o	o			o	o	o						
d) Develop cost-feasibility criteria	o	o	o	o	o	o			o	o		o	o			o	o	o			o			
e) NSF authorized to accomplish the above	o	o	o	o	o	o			o	o	o	o	o			o	o	o			o		o	o
2. Establish natural hazard zone model	o	o	o	o	o	o			o	o		o				o		o						o
3. Study state and local hazards management capacity	o	o	o				o	o		o	o					o	o			o				
4. Determine content and applicability of codes and regulations	o	o	o				o			o					o	o	o			o	o			
5. Develop state and local training programs	o	o	o				o		o	o	o	o	o		o	o	o				o			o
6. Natural hazard public information program	o	o	o	o	o	o	o	o	o	o						o	o	o	o		o			o
7. Determine feasibility of natural hazard insurance	o	o		o	o	o	o	o	o	o								o	o	o		o	o	
8. Identify costs externalized to non-risk-takers						o	o	o	o	o						o			o	o	o	o	o	o
9. Specific measures for high-hazard counties	o	o		o	o	o	o	o	o	o											o			
PHASE 2: 1. Require full disclosure of natural hazards risks	o	o			o	o	o		o	o									o				o	
2. Require participation of beneficiary parties			o	o		o	o		o							o	o	o	o	o				
3. Highway signs indicating hazard zones	o	o	o																o	o				
4. Require building strengthening where cost-feasible	o	o	o	o	o	o	o	o		o						o		o	o	o		o		
5. Foster use of "highest not savings" mitigations	o	o		o	o	o				o							o			o	o			
6. Require hazard impact and mitigation statements	o	o	o			o	o		o	o	o	o	o	o	o	o		o	o	o				
PHASE 3: 1. Implement natural hazards insurance program	o	o		o	o	o	o	o										o	o			o		
2. Require cost sharing of post-disaster relief services						o	o		o								o	o	o				o	
3. Adopt national natural hazards management act	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
RECOMMENDATIONS FOR STATE ACTION																								
1. Protect Tsunami inundation area	o	o	o	o	o	o			o	o											o			
2. Apply mitigations to coastal flood plains	o	o	o	o	o	o			o	o	o	o	o	o	o	o	o	o			o			
3. Adopt state natural hazard management acts	o	o				o	o	o	o	o									o				o	
4. Building and housing code requirements	o	o	o	o	o	o	o	o	o	o					o	o	o	o			o		o	
5. Subdivision applications to include hazard impact statement	o				o	o	o	o		o							o	o	o	o			o	
RECOMMENDATIONS FOR LOCAL UNITS OF GOVERNMENT																								
1. Identify natural hazard zones and exposures	o	o																o	o			o		
2. Identify natural hazard zones in master plan	o	o	o			o											o	o						
3. Adopt local natural hazards management program	o	o	o	o	o	o	o			o					o	o	o	o						
4. Mitigation policy as part of subdivision ordinances	o				o	o	o			o							o	o				o		
5. Periodic review of hazard zones and management plans	o	o				o																		
6. Identify natural hazard uses of IPA and CTA funds																	o							
RECOMMENDATIONS FOR ACTION BY PRIVATE ENTITIES																								
1. AAAS Commission on Management of Environmnetal Hazard Zones	o	o				o					o	o	o	o						o				o
2. Committee on Natural Hazard Management Criteria and Research	o	o				o					o	o	o	o						o				o

Figure 22. Intended Candidate Public Problem Targets of Natural Hazard Policy Recommendations

REFERENCES

Project Reports (NSF Grants ERS-75-09998-A01 and AEN-74-23992)

Hart, Gary C. Natural Hazards: Tornado, Hurricane, Severe Wind Loss Models. Redondo Beach, California: J.H. Wiggins Company, 1978.

Hirschberg, J.P., P. Gordon and W.J. Petak. Natural Hazards: Socioeconomic Impact Assessment Model. Redondo Beach, California: J.H. Wiggins Company, 1978.

Lee, Larry T., John D. Chrostowski and Ronald Eguchi. Natural Hazards: Riverine Flooding, Storm Surge, Tsunami Loss Models. Redondo Beach, California: J.H. Wiggins Company, 1976.

Petak, William J., Arthur A. Atkisson, Paul H. Glye. Natural Hazards: A Building Loss Mitigation Assessment (Final Project Report). Redondo Beach, California: J.H. Wiggins Company, 1978.

Wiggins, J.H., J.E. Slosson and J. Krohn. Natural Hazards: Earthquake, Landslide, Expansive Soils Loss Models. Redondo Beach, California: J.H. Wiggins Company, 1978.

Other References

Advisory Commission on Intergovernmental Relations. Building Codes: A Program for Intergovernmental Reform. Washington, D.C.:1966.

American Insurance Association. National Building Code. New York: the Association, 1976.

American National Standards Institute, Inc. "American National Standards Building Code Requirements for Minimum Design Loads in Buildings and Other Structures." NASI Publication, A58-1-1972. New York, 1972.

American Society of Planning Officials. The Text of a Model Zoning Ordinance, 3rd Edition. Washington D.C.: ASPO, 1966.

Anderson, James E. Public Policy Making. New York: Praeger Publishers, 1975.

Anderson, Robert M. American Law of Zoning, Vol. 1. Rochester, N Y.: Lawyers Cooperative, 1968.

Armstrong, Joe E. and Willis W. Harmon. Strategies for Conducting Technology Assessments. Department of Engineering - Economic Systems, Stanford University, 1977.

Bartee, E.M. "A Holistic View of Problem-Solving." Management Science, Vol. 20, No. 4. December 1972, pp 439-447.

Bates, F.L. et al. The Social and Psychological Consequences of a Natural Disaster: A Longitudinal Study of Hurricane Audrey. National Research Council Disaster Study #18. Washington, D.C.:National Academy of Sciences, 1963.

Beyer, Glenn H. Housing and Society. New York: The MacMillan Co., 1968.

Building Officials and Code Administrators International, Inc. BOCA Basic Building Code. Chicago, 1975.

Buoh, Vincent R. and J.E. Bihr. "Uniform Building Code for Wind Loading." Meeting Preprint 7621. ASCE National Convention, Denver, Colorado, Nov. 1975.

Burton, Ian and Robert W. Kates. "The Perception of Natural Hazards in Resource Management." Natural Resource Journal, #3, pp 412-441, 1964.

Burton, Ian, et al. "The Shores of Megalopolis: Coastal Occupance and Human Adjustment to Flood Hazard." Climatology, Vol. 18, #3. Elmer, New Jersey: C.W. Thortwaite Associates, 1965.

Burton, Ian, Robert W. Kates and Gilbert F. White. The Human Ecology of Extreme Geophysical Events. Natural Hazards Research Working Paper #1. Toronto: University of Toronto Department of Geography, 1968.

Clapp, Charles L. "The Congressman as a Legislator." In Samuel C. Patterson (ed), American Legislative Behavior: A Reader. Princeton, New Jersey: D. Van Nostrand Company, Inc. 1968.

Coase, R.H. "The Problem of Social Cost." The Journal of Law and Economics, Vol. III, October 1960.

Coates, Joseph F. "The Role of Formal Models in Technology Assessment." Technology Forecasting and Social Change, Vol. 9, 1976.

Cobb, Roger W. and Charles D. Elder. Participation in American Politics: The Dynamics of Agenda Building. Boston: Allyn and Bacon, 1972.

Cochrane, Harold C. Natural Hazards and Their Distributive Effects. Institute of Behavioral Science, University of Colorado, Program on Technology, Environment and Man, Monograph No. NSF-RA-E-75-003, p. 58, 1975.

Council on Environmental Quality. Second Annual Report . Washington, D.C.: U.S. Government Printing Office, 1971.

Council on Environmental Quality. Seventh Annual Report. CEQ. Executive Office of the President. Washington, D.C.: USGPO, 1977.

Council on Environmental Quality. Ninth Annual Report. Executive Office of the President. Washington, D.C.: USGPO, 1977.

Dacy, Douglas C. and Howard Kunreuther. The Economics of Natural Disasters, Implications for Federal Policy. New York: The Free Press, 1969.

Davies, Jack. Legislative Law and Process in a Nutshell. St. Paul, MN: West Publishing Company, 1975.

Dewey, John. The Public and Its Problems. Denver: Swallow Publishers, 1954.

Dexter, Lewis Anthony. How Organizations are Represented in Washington. Indianapolis: Bobbs-Merrill, 1969.

Federal Register. Vol. 40, No. 214, December 18, 1975.

Field, Charles G. and Steven R. Rivkin. The Building Code Burden. Lexington, Mass.:D.C. Heath, 1975.

Greenwald, Carol S. Group Power: Lobbying and Public Policy. New York: Praeger, 1977.

Gross, Robert N. "Cost Benefit Analysis of Health Service." Annals of the American Academy of Political and Social Science, Vol. 399, January 1972.

Hagman, Donald G. Public Planning and Control of Urban Land and Development. St. Paul, MN.: West Publishing, 1973.

Halstead, Murat. Galveston: The Horrors of a Stricken City. American Publishers Association, 1900.

Hemphill, John A. "Administration as Problem Solving." Edited by Andrew W. Halperin. Administrative Theory in Education. New York: The MacMillan Co., 1967.

International Conference for Building Officials. Uniform Building Code, 1975 Edition. Whittier, California: the Conference, 1976.

Johnson, William K. Physical and Economic Feasibility of Nonstructural Flood Plain Management Measures. Ft. Belvoir, VA: U.S. Army Corps of Engineers, Institute for Water Resources, March 1978.

Jones, Charles O. An Introduction to the Study of Public Policy. No. Scituate, MA: Duxbury Press, 1977.

Insurance Information Institute. Insurance Facts 1971. New York, 1971.

International Conference for Building Officials. Uniform Building Code, 1975 Edition. Whittier, California: the Conference, 1976.

Kates, R.W. "Natural Hazards in Human E cologic Perspective: Hypotheses and Models." Economic Geography, Vol. 47, pp 438-451, 1971.

Keefe, Wm. J. and Morris S. Ogul. The American Legislative Process. 4th Ed., Englewood Cliffs, New Jersey, Prentice-Hall, 1977.

Kusler, Jon A. and Thomas M. Lee. Regulations for Flood Plains, Chicago:ASPO Press, 1972.

Kusler, J.A. Statutory Land Use Control Enabling Authority for the Fifty States, with special reference to Flood Hazard Regulatory Authority, HUD, Federal Insurance Administration, 1976.

Lesso, William G. Potential Wind Damage Reduction Through Use of Wind-Resistant Building Standards. Austin, Texas: Texas Coastal and Marine Council, 1976.

Los Angeles Times. "Carter Orders Check of High-Hazard Private Dams." Part II, p. 8, November 29, 1977.

Lowi, Theodore J. "American Business, Public Policy, Case Studies and Political Theory." World Politics, Vol. 16, pp 677-715, 1964

Mann, Dean E. "Political Incentives in U.S. Water Policy: Relationships between Distributive and Regulatory Politics." In Matthew Holden, Jr. and Dennis L. Dresang (Eds.) What Government Does. Beverly Hills: Sage, 1975.

Mayhew, David R. Congress: The Electoral Connection. New Haven: Yale, 1974.

Mileti, Dennis S., Thomas E. Drabek and Eugene J. Haas. Human Systems in Extreme Environments: A Sociological Perspective. University of Colorado: Institute of Behavioral Science, 1975.

Miller, Crane H. Flood Plain Management; Issues and Alternatives for the Congress. Prepared for the U.S. Office of Technology Assessment, 1978.

Municipal Manpower Commission. Governmental Manpower for Tomorrow's Cities: A Report of the Municipal Manpower Commission. New York: McGraw-Hill, 1962.

National Commission on Urban Problems. Building the American City. Washington, D.C.: USGPO, 1968.

National Commission on Urban Problems. How the Many Costs of Housing Fit Together: Research Report No. 16. Washington, D.C.: U.S. Government Printing Office, 1969.

National Commission on Urban Problems. Local Land and Building Regulation: Research Report No. 6, Washington, D.C.: U.S. Government Printing Office, 1968.

National Safety Council. Accident Facts 1971. Chicago, 1971.

National Safety Council. Accident Facts 1975. Chicago, 1975.

Office of Emergency Preparedness. Disaster Preparedness: Report to the Congress. Washington, D.C.: Executive Office of the President. January 1972.

Olson, Mancur, Jr. The Logic of Collective Action: Public Goods and the Theory of Groups. New York: Schocken Books. 1971.

Ong, John N., Jr. and Arthur Atkisson. "The Nature of Problems and Problem Identifying Concepts and Methods." Problem Analysis and Decision Making. University of Wisconsin, Board of Regents, 1976.

Platt, Rutherford H. "The National Flood Insurance Program, Some Midstream Perspectives." Journal of the American Institute of Planners, Vol. 42, No. 3, pp 303-313. July 1976.

Quarantelli, E.L. and Russell R. Dynes. Images of Disaster Behavior: Myths and Consequences. The Ohio State University: Disaster Research Center, 1973.

Ripley, Randall B. and Grace A. Franklin. Congress, The Bureaucracy and Public Policy. Homewood, Illinois: Dorsey Press, 1976.

Roder, Wolf. "Attitudes and Knowledge on the Topeka Flood Plain." In G.F. White, (Ed.) Papers on Flood Problems. Department of Geography Research Paper #70, Chicago: University of Chicago, 1961.

Rogers, W.P. et al. Guidelines and Criteria for Identification and Land Use Controls of Geologic Hazard and Mineral Resource Areas. Denver: Colorado Geological Survey, Department of Natural Resources, 1974.

Rossi, Peter, et al. "Are There Long-term Effects of American Natural Disasters?" Journal of Mass Emergencies, forthcoming 1979.

Saarinen, Thomas F. Perception of Drought Hazard on the Great Plains. Dept. of Geography Research Paper #106. Chicago: University of Chicago, 1966.

Salisbury, Robert and John Heinz. In Ira Sharkansky, (Ed.) Policy Analysis in Political Science. Chicago: Markham, 1968.

Schattscheneider, E.E. The Semisovereign People. New York: Holt, Rinehart and Winston, 1960.

Schneider, William J. and James E. Goddard. Extent and Development of Urban Flood Plains. Geological Survey Circular 601-J, Washington, D.C.:U.S. Geological Survey, 1974.

Slosson, James E. and James P. Krohn. "Landslide Potential in the United States." California Geology, Vol. 29, No. 10, 1966.

Slosson, J.E. "The Role of Engineering Geology in Urban Planning: The Governor's Conference on Environmental Geology." Colorado Geological Survey Special Publication No. 1, pp 8-15, 1969.

Slosson, James E. "Legislation Related to Earthquakes." California Geology, p. 37. February 1975.

Slosson, James E. and James P. Krohn. "Effective Building Codes." California Geology, pp 136-139, June 1977.

Slovic, P., B.Fischoff and S.Lichtenstein. "Cognitive Processes and Societal Risk Taking." In J.S. Carroll and J.W. Payne, (Eds.) Cognition and Social Behavior. Potomac, Maryland: Lawrence Erlbaum Associates, 1976.

Solomon, K.A. and D. Okrent. Seismic Building Codes for the City of Los Angeles, California. Brief Case Study. Rand report #P-6018, November 1977.

Southern Building Code Congress International, Inc. Standard Building Code, 1976 Edition. Birmingham, Alabama: The Congress, 1976.

Steinbrugge, Karl V. Earthquake Hazards Reduction: Issues for an Implementation Plan. Working Group on Earthquake Hazards Reduction, Office of Science and Technology Policy, Executive Office of the President, Washington, D.C., 1978.

Texas Coastal and Marine Council. Hurricane Resistant Building Standards and Natural Hazards. Austin, Texas, 1977.

Texas Coastal and Marine Council. Model Minimum Hurricane Resistant Building Standards for the Texas Gulf Coast. Austin, Texas, 1976.

Thom, H.C.S. "New Distribution of Extreme Winds in the United States." J. Struc. Div. ASCE, Vol. 87, No. ST7, pp 1787-1801, July 1968.

United Nations Office of the U.N. Disaster Relief Coordinator. Guidelines for Disaster Prevention, 3 Volumes. Geneva, 1976.

U.S. Army Corps of Engineers. Final Report of the Chief of Engineers on Civil Works Activities, 1974-5.

U.S. Army Corps of Engineers. Report on Hurricane Camille, August 14-22, 1969. Mobile, Alabama: U.S. Army Engineer District, 1969.

U.S. Congress. Insurance and Other Programs for Financial Assistance to Flood Victims. 89th Congress, Print No. 43. Committee on Public Works, 1966.

U.S. Congress. Technology Assessment in Business and Government. Joint Office of Technology Assessment. Washington, D.C.:U.S.G.P.O., 1977.

U.S. Congress. Senate Committee on Banking and Currency. Insurance and Other Programs for Assistance to Flood Victims. Department of Housing and Urban Development Report, Washington, D.C., 1966.

U.S. Congress. Senate Committee on Banking, Housing and Urban Affairs. Oversight on Federal Flood Insurance Programs. 94th Congress, 1st Session, 1975.

U.S. Department of Commerce. An Inquiry into the Long-Term Economic Impact of Natural Hazard Management in Coastal Areas, 1976.

U.S. Department of Commerce, National Oceanic and Atmospheric Administration. Natural Hazard Management in Coastal Areas, 1976.

U.S. Department of Urban Development, Federal Housing Administration. Minimum Property Standards for One and Two Living Units. Re!ort Number 300, Washington, D.C., 1966.

U.S. Office of Emergency Preparedness, Executive Office of the President. Disaster Preparedness. Washington, D.C.:U.S.G.P.O., 1972.

U.S. Water Resources Council. Options for Cost Sharing. Part 5A, Table 5A-1, Washington, D.C., 1975.

U.S. Water Resources Council. Planning and Cost Sharing Policy Options for Water and Related Land Programs, Supplementary Information. Part 8C. Washington, D.C., 1975.

U.S. Water Resources Council. Principles and Standards for Planning Water and Related Land Resources. Washington, D.C., 1973.

U.S. Water Resources Council. A Unified National Program for Flood Plain Management. Washington, D.C., 1976.

Vogler, David J. The Politics of Congress. 2nd Edition, Boston: Allyn and Bacon, 1977.

White, Gilbert F. and Eugene J. Haas. Assessment of Research on Natural Hazards. Cambridge, Mass.: The MIT Press, 1975.

White, Gilbert F. et al. Changes in Urban Occupance of Flood Plains in the United States. Department of Geography Research Paper #57. Chicago: University of Chicago, 1958.

White, Gilbert F. Choice of Adjustment to Floods. Department of Geography Research Paper #93. Chicago: University of Chicago, 1964.

White, Gilbert F. "Flood Hazard in the United States: A Research Assessment." University of Colorado Monograph NSF-RA-E-006. 1975.

White, Gilbert F. (Ed.) Natural Hazards: Local, National, Global. New York: Oxford University Press, 1974.

White, Gilbert F. Natural Hazard Management in Coastal Areas. Prepared for the U.S. Department of Commerce, Office of Coastal Zone Management, 1976.

Williams, Lawrence A., Eddie M. Young and Michael A. Fischetti. Survey of the Administration of Construction Codes in Selected Metropolitan Areas. A report prepared for the National Commission on Urban Problems, Springfield, VA., Clearinghouse for Scientific and Technical Information, 1968.

Wright, Richard, Samuel Kramer and Charles Culver (Eds.) Building Practices for Disaster Mitigation (National Bureau of Standards Building Series 46). Washington, D.C.:U.S. Government Printing Office, 1973.