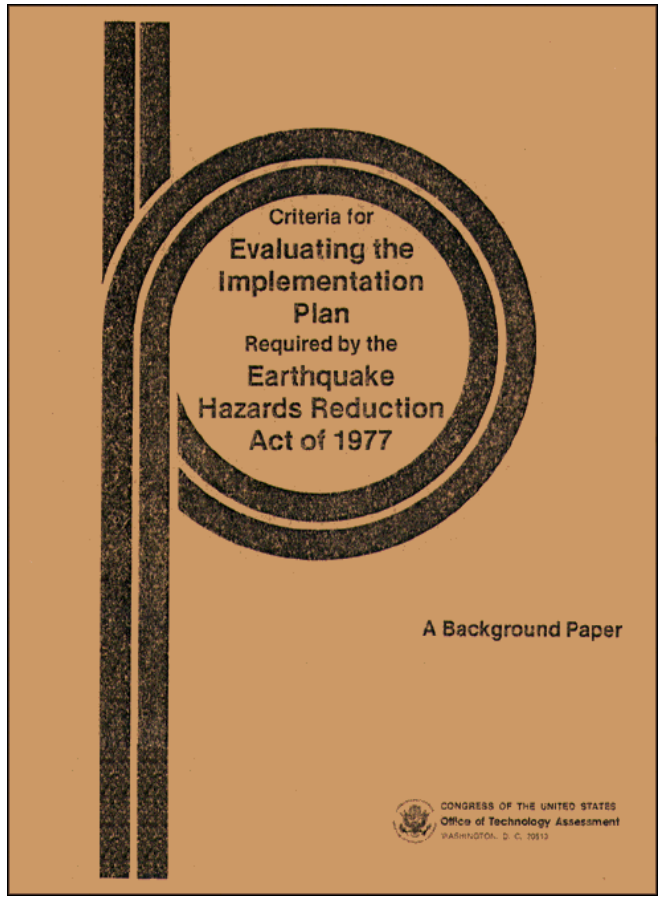
Criteria for Evaluating the Implementation Plan Required By the Earthquake Hazards Reduction Act of 1977

January 1980

NTIS order #PB81-241663



Preface

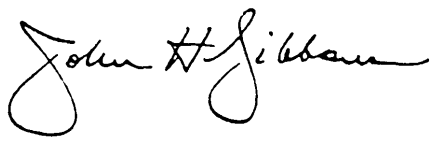
Congressman Thomas L. Ashley, Chairman of the House Subcommittee on Housing and Community Development and Senator William Proxmire, Chairman of the Senate Committee on Banking, Housing, and Urban Affairs and member of the Senate Committee on Appropriations, requested that the Office of Technology Assessment (OTA) undertake a study in the area of natural hazards. In response, OTA initiated a preliminary analysis to define what issues are or would be of congressional concern and where further study could be useful.

This Background Paper, "Criteria for Evaluating the Implementation Plan Required by the Earthquake Hazards Reduction Act of 1977," is one result of that analysis.

For this study, a working paper was prepared as the basis for a workshop, which included a broad sweep of stakeholders in the public and private sectors, scholars concerned with the field, and members of various congressional committee staffs. On the basis of that workshop's recommendations, a revised working paper was prepared and sent to all participants, and to dozens of other experts, for extensive review. and comment. The final background paper is the responsibility of OTA, not of those who so ably advised us on its preparation.

After the completion of the work reported in this paper (May 1, 1978), the President transmitted to Congress a plan for a National Earthquake Hazards Reduction Program (June 22, 1978). This OTA paper was made available to and used by staff members of both the Senate Commerce, Science, and Transportation Committee and the House Committee on Science and Technology, in their evaluations of the implementation program. This OTA document may be of continuing use to the committees in their oversight and it may also assist the executive branch and State agencies in the evolution of their programs. (The President's Earthquake Hazards Reduction Program accompanies this background paper as an appendix.)

In addition to the general acknowledgment of the indispensable services to this project of the workshop attendees, the OTA staff wishes to express appreciation for the assistance and cooperation of the following individuals as reviewers, readers, commentators, and sources of information with regard to this document and previous draft materials: Gilbert White, University of Colorado; John Wiggins, Wiggins Associates, Redondo Beach, Calif.; Charles Thiel, National Science Foundation; and Charles Fritz, National Academy of Sciences.



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Introduction

The Earthquake Hazards Reduction Act of 1977 (Public Law 95-124) proposes to reduce the risk to life and property from future earthquakes by establishing and maintaining an earthquake hazards reduction program. The Act also required that an implementation plan be submitted to Congress within 210 days of enactment. That has been done, and the plan is included in this paper as an appendix.

This paper identifies 14 basic issues or conflicts with which the implementation plan must cope in order to achieve its objectives. These issues and the associated questions developed under each of them in the text comprise criteria which may be useful to Congress in its evaluation of the plan.

The issues, while all basic to a successful program, are arranged in a rough descending order of their importance to a successful program.

1. Federal vs. State and Local Responsibilities
2. Earthquake vs. An All Natural Hazards Strategy
3. Narrowing Choices v's. Widening Choices: The Acquisition of Information
4. Narrowing Choices vs. Widening choices: The Role of Dissemination and Utilization of Knowledge
5. Engineering Design vs. Scoioeconomic Strategies
6. Life Safety vs, Property Value-Oriented Programs: Balancing Needs
7. Life Safety vs. Property Value-Oriented Programs: Hazardous Buildings
8. Federal Regulations Overriding Conflicting State Law vs. State-by-State Resolution: Building Codes
9. Prediction vs. Present Capabilities
10. The Picture of the Present vs. The Images of the Future: Choosing Alternatives
11. The Picture of the Present vs. The Images of the Future: Resolving Ambiguities
12. The "Normal" Disaster vs. The Catastrophe
13. Interagency Conflicts: New vs. Existing Agencies
14. Urgency of Need vs. Limited Capabilities

The issues are treated in this sequence in the summary (pages 3-6) and in expanded form in the text, pages 17 to 36.

L Summary

The Earthquake Hazards Reduction Act of(1977 (Public Law 95-124) proposes to reduce the risk to life and property from future earthquakes by establishing and maintaining an earthquake hazards reduction program. The implementation plan required by the Act to direct these activities has been submitted to Congress. Within 300 days of enactment, the President must designate a lead agency, assign responsibilities in the program to appropriate agencies, and establish goals and target dates for the program.

Congress required the implementation plan to deal with:

- preparations for earthquakes, including prediction, evaluation, earthquake warnings, and response planning;
- development of ways for State and local government to use information about earthquake risks in land use planning;
- development of standards and codes for earthquake-resistant construction;
- examination of how earthquake hazards can be reduced through Federal construction loans and licenses;
- determination of the appropriate roles of insurance loans and relief in moderating the impact of earthquakes; and
- dissemination of information about all aspects of earthquakes.

This paper identifies 14 basic issues with which the implementation plan must cope in order to achieve its objectives. These issues and the associated questions developed under each of them comprise criteria against which the plan may be evaluated. Consequently, this paper is intended to assist the committees of Congress in their evaluation of the plan. This paper was prepared independent of the implementation plan and without knowledge of its proposed contents.

The issues, while all basic to a successful program, are arranged in a rough descending order of importance of their resolution to a successful program.

The issues are treated in detail in the same sequence on pages 17 to 36.

FOURTEEN KEY ISSUES

Issue 1: Federal vs. State and Local Responsibilities

The tensions evoked by the division of power and responsibility among the various levels of Government involved in earthquake hazards reduction should be resolved.

The Federal agencies would consider it most convenient if their initiatives took priority and were uniform across the country. This would ignore regional and local differences in awareness, perspective, extent of hazard, competing objectives, and differences in distribution of power and responsibility.

Issue 2: Earthquake vs. An All Natural Hazards Strategy

While it may be convenient for researchers and the large Federal agencies to handle hazards categorically, the practicalities of State and local government organization and function increasingly require integrated planning and operations for all hazards. Similarly, Federal construction and housing programs also could be responsive to all hazards not just to one or a few selected hazards.

Issue 3: Narrowing Choices vs. Widening Choices: The Acquisition of Information

There are three aspects of the acquisition of information with which the implementation plan should be concerned:

- Quality of Past Information.—Theories about the behavior of faults, of structures, and of people based on information gathered in the past may prove false and, in turn, lead to actions wasting money and effort and even endangering lives and property.
- Adequacy of Current Information for Program Planning.—Successful execution of the implementation plan will depend upon coordination of a myriad of Federal, State, and local laws related directly or indirectly to earthquake hazards reduction. Conflict could

easily arise with flood control, environmental policy, historical preservation, building codes, and land use planning policies.

- Providing for Future Information.—Explicit planned decisions on what information should be sought i n further research are essential to steady progress in earthquake hazards reduction.

New problems, such as those arising from new technologies, may require innovative approaches and creative solutions. Established bureaucracies, however, tend to restrict fundin g to "tried and true" methods.

People are keys to information use. Therefore, future needs for professionals in architecture, planning, emergency preparedness, and many other related fields should be ascertained and plans made so that an adequate number of persons can he trained.

Issue 4: Narrowing Choices vs. Widening Choices: The Role of Dissemination and Utilization of Knowledge

Another basic conflict involves the balance between legislative or regulator imposition of solutions and the dissemination of needed information to local and State entities that can then use the data to work out their alternatives and influence the selection among them.

There is need for a mechanism by which users and their particular needs can be identified. Prior research has yielded data that is not being put to use. At the same time, action sometimes occurs prematurely in areas where more or better quality research could lead to more rational and effective solutions.

The citizen who wants to be involved in local planning and decisionmaking also needs good information keyed to the nonspecialist. Here the Federal specialist can be invaluable as an advisor and information source.

Issue 5: Engineering Design vs. Socioeconomic Strategies

Because they behave in a logical, consistent, predictable manner, yield easily quantifiable data, and perform their tasks unaffected by emotions or value judgments, mechanical devices and engineered structures tend to appeal to public officials and other decisionmakers.

However, effective community decisionmaking requires that community experience and values be applied to problem-solving through management of human systems, i e. , social, economic, legal, and political systems.

A good historical example of the conflict between the engineering and management approaches can be found in the changing attitudes toward adjustments to flood hazards, where dam building is being supplanted by insurance and land management strategies. The clear need is for an integrated plan of complementary strategies.

Issue 6: Life Safety vs. Property Value-Oriented Programs: Balancing Needs

No implementation plan would be written deliberately to place lives in jeopardy or to protect one class or group at the expense of others. However, it is quite possible that the ultimate effect of certain procedures, regulations, or policies may be just that, On the other hand, when the emphasis is only on preventing death and injury, there is a tendency to take only those minimum measures which protect life, rather than to look beyond the minimum in order to protect the community's economic health after the quake. Measures to limit potential economic losses usually will require more stringent construction and sitin g control than is necessary to achieve only life safety objectives.

Issue 7: Life Safety vs. Property Value-Oriented Programs: Hazardous Buildings

The single greatest life-threatenin g earthquake hazard, and the one most difficult to alleviate, is the old, unreinforced masonr y building. There are hundreds of thousands of these in quake-prone cities. In a major earthquake, they would be deathtraps. Their collapse would also create debris barriers that firefighters and emergency rescue vehicles could not pass.

Yet, these buildings represent sizable real estate investments, often by owners unable or unwilling to finance the retrofit or replacement. They are homes to those who lack the money and/or the desire to live elsewhere. Some of these buildings offer historic and esthetic values to communities which wish to preserve them, but lack the means to bring them "up to code."

These buildings constitute a hazard too great to be ignored, but too expensive for individual owncrs or communities to alleviate within a short time.

Issue 8: Federal Regulations Overriding Conflicting State Laws vs. State-by-State Resolution: Building Codes

Building codes are the single most important, direct way to mitigate earthquake hazards.

Some States have statewide building codes, others leave code adoption and enforcement to individual counties and cities, some of which have no building codes at all. Most emphasis has been placed on the supporting structure of buildings, neglecting nonstructural components. There is a pressing need for more attention to code and design requirements for nonstructural elements, especially for "lifeline systems," i.e., essential public service delivery systems such as transportation, communications, and utilities.

All building codes, whatever their emphasis, tend toward only minimum life safety standards. Mistakenly, public decisionmakers and their constituents often believe that codes are all-inclusive and all-protective. The timelag between technological developments and their appearance in the codes is often great. Even when new developments are incorporated in the Uniform Building Code, few States require that local jurisdictions update their versions of the code.

Issue 9: Prediction vs. Present Capabilities

Reasonably accurate and useful means of earthquake predict ion mav not 1 lie far in the future. Still, it is unlikely that earthquakes will be predicted usefully or reliably by the time the initial appropriation for Public Law 95- 124 expires. In addition, predictive methods that work i n one geophysical province may not work in another. The need to plan for the wise use of earthquake prediction should not blind decisionmakers to the present problem of how to cope until such measures become available. In addition, studies to date suggest major new consequences–both beneficial and detrimental–of prediction, which in turn require further study.

The plan must resolve the tension between developing future prediction capability and dealing with quakes likely to occur before that capability is at hand. The need to mitigate basic structure loss, however, will not be reduced by development of a predictive capability, as prediction, alone, cannot reduce damage vulnerability of building stocks.

Issue 10: The Picture of the Present vs. The images of the Future: Choosing Alternatives

Present public policy actions are unlikely to hate a great effect on the quality of life or the public well-being in the short term. Their major effects, both planned and unplanned, will be in the future. It is useful, therefore, to look to the future and make explicit the assumptions about the future world which guided the plan.

Issue 11: The Picture of the Present vs. The Images of the Future: Resolving Ambiguities

The Act states that "It is the purpose . . . to reduce risks . . . from future earthquakes i n the United States . . . "

Neither the faults that cause earthquakes nor the damages that result from seismic activity respect national boundaries. Thus, a quake with a U.S. epicenter may cause damage in Canada and Mexico, or a quake with an epicenter in Kamchatka may cause damage along the western coast of the United States. A n earthquake orginating beneath international waters may cause tsunami along U.S. shores. The intent of the Act regarding these conditions is not clear.

Were these or other ambiguities identified by the plan? Do they suggest a need to return to Congress for clarification?

Issue 12: The "Normal" Disaster vs. The Catastrophe

A maximum credible disaster—a disaster taking thousands of lives and running into tens of billions of dollars—implies a major discontinuity of economic and community life. On the other hand, the Government desires to maintain a comfortable sense of continuity of institutions. It would be worthwhile to identify a threshold of disaster requiring an extended recovery period, during which the normal operating laws, rules, and regulations of society would need to be suspended. This concept would go well beyond martial law

and suggests that debts, insurance, bank payments, commercial obligations, and so on might be handled in a unique way. A model for this would be postwar European recovery. Such a straregy might address many of the difficulties that the disruption a major disaster (or its prediction) might unleash upon the whole United States or a regional economy.

This conflict between saving lives and restoring the economic balance of the country (or a region) on the one hand, and the constitutional questions raised by such extreme solutions on the other, requires careful analysis and anticipatory planning.

Issue 13: Interagency Conflicts: New vs. Existing Agencies

Public Law 95-124 provides for leadership to coodinate the efforts of the man}' agencies. Most States already have agencies responsible for emergenccy preparedness, environmental concerns, and geologgy, and these have ties with Federal agencies having implementation responsibilities.

Interaction among the several State agencies, and between State and local bodies, ranges from cooperation to competition so intense that it impedes effective action.

It may be that the only solution in some States will be to consolidate all earthquake planning functions into one new agency. In others, varying degrees of consolidation and coordination should develop. In still other States, effective interagency programs may already be functioning.

Existing agencies at both Federal and State levels have the advantage of experienced personnel familiar with problems and procedures. On the other hand, these bureaucracies may overcommit themselves to their own sets of regulations and priorities. The implemental ion plan must achieve balance among these conditions in order for the legislation to be effective.

Issue 14: Urgency of Need vs. Limited Capabilities

It is often widely believed that brief, all-out efforts can solve major problems or accomplish great feats. Unfortunately, this has rarely proved to be the case.

Congress (and the President) will need to be apprised of the success or failure of the plan from time to time, and certainly by the end of the initial appropriation period.

If the plan is succeeding, then some measure of its success must be made available. If the plan is not achieving any of its aims, it must be recast or abandoned.

II. The Earthquake Hazards Reduction Act of 1977, Public Law 95=124

INTRODUCTION

The Act is a major legislative recognition of the extensive risk to lives and property from earthquake hazards in the United States. As a result of the shift of our growing population toward high-density urban living, and as a result of population growth in regions with seismic activity in historic time, there is a prospect of catastrophic earthquakes leaving thousands dead, destroying tens of billions of dollars in property, and causing social Dislocation on a massive scale. The Earthquake Hazards Reduction Act is an attempt to coordinate existing programs and begin to allocate funds In a manner comparable with the gravity of the problem.

The purpose of the Act is to reduce the risks to life and property from earthquakes in the United States through the establishment of an effective earthquake hazards reduction program.

Scientific advance and research findings have made it possible for public policy to aim. at mitigation of hazards-related losses. Thus, it is no longer necessary for public policy to limit itself to the traditional emphasis on postdisaster relief and reconstruction. Scientific and engineering achieve ments, especially in the moderation, prevention, and prediction of seismic risks, have critical implications for the future of earthquake hazards ma management. The Act reflects the need for a coherent national framework, within which these emerging technologies can mature and be useful.

The growth in public awareness of U.S. exposure to earthquake hazards—at least 39 States face severe or moderate risks (figure 1)—has spurred engineers and social scientists to inquire about engineering and management techniques applicable to the mitigation of the effects of seismic events. This fertile research area is just beginning to receive the financial support commensurate with the importance of its mission.

For the results of this research to be effective, knowledge must be aggregated and evaluated for its applicability in hazard situations and actively disseminated to the appropriate governmental jurisdiction and to the population at largc. Any coherent nationa I planning program must frame the reduction of earthquake hazards in such a manner that fragmentation is limited and coordination enhanced. This legislation seeks to establish that framework to harness the dispersed energies of the many scientists, engineers, builders, and planners already involved in the attempt to reduce this Nation's sensitivity to earthquake hazards.

CONTENTS OF THE ACT

The Act establishes a national earthquake hazards reduction program, under the direction of the President, to minimize the loss and disruption resulting from future earthquakes. The program includes four parts.

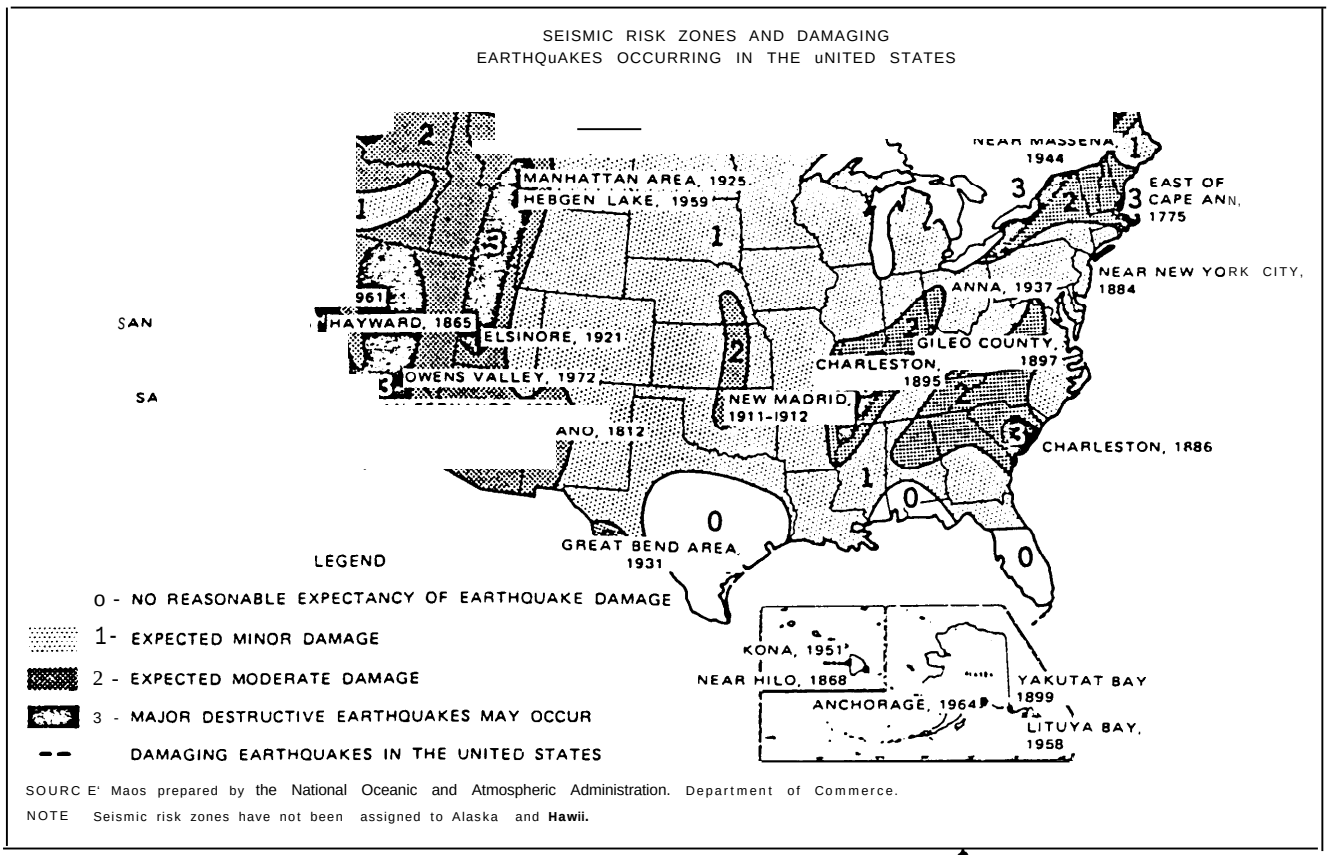
The first element includes fundamental earthquake studies, prediction, hazards assessment, and other research relating to the reduction of hazards.

Because we need more knowledge about all aspects of earthquakes, the Act requires research in nine areas:

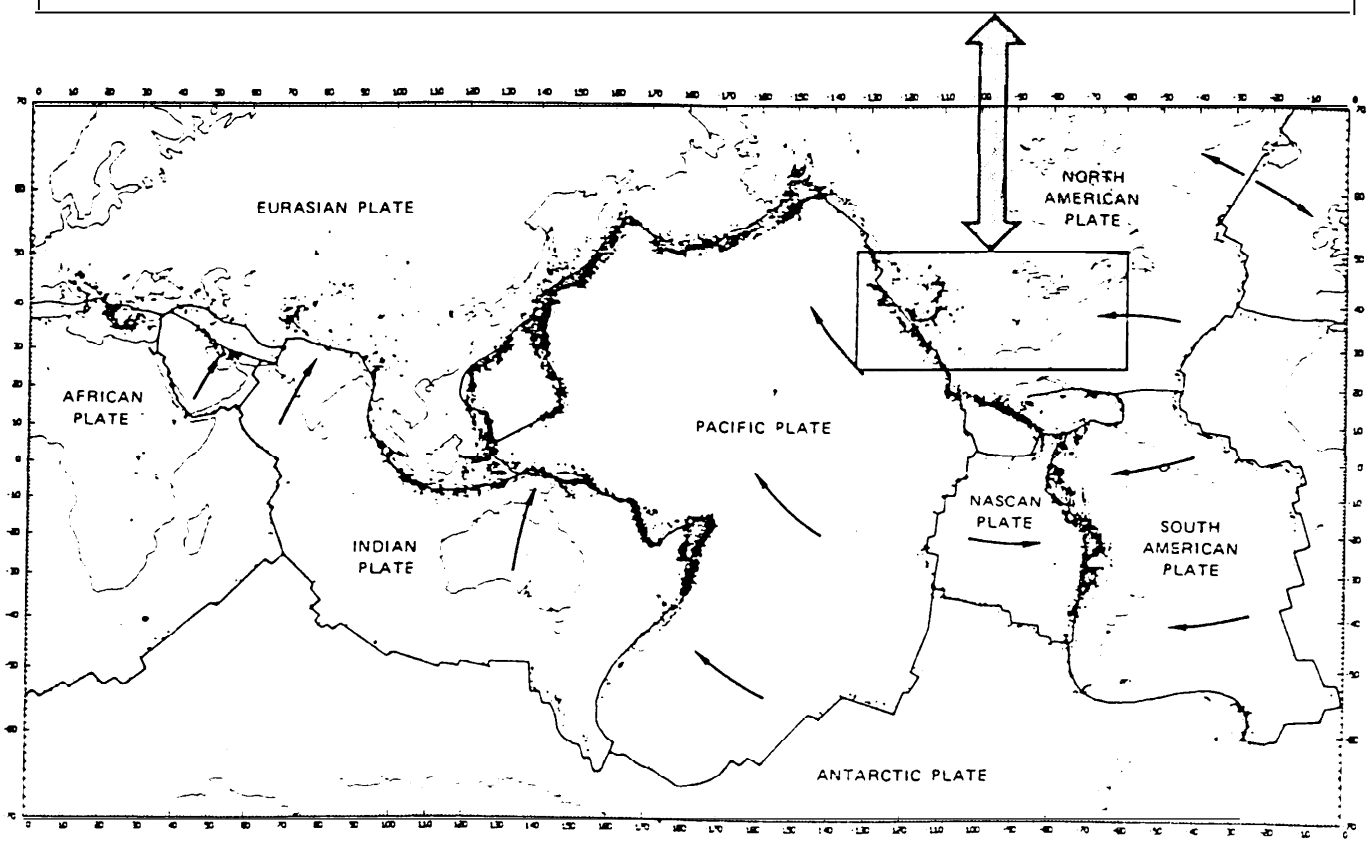
1. basic earthquake causes;
2. earthquake prediction;
3. artificial induction of earthquakes;
4. earthquake modification or control;
5. preparation of risk analyses a and land use guidelines;
6. earthquake effects;
7. methods of designing and building manmade works to resist earthquakes;
8. social and economic adjustments that would lessen the harm done by earthquakes; and
9. foreign experience with earthquakes.

A second element of the Act calls for an implementation plan for applying the existing information and new research findings to decision-making at the Federal, State, and local levels. This plan was required to be submitted to Congress

Figure 1.—Map of Worldwide Seismic Activity Showing Location and Movement of Major Plates



SOURC E' Maos prepared by the National Oceanic and Atmospheric Administration. Department of Commerce.
NOTE Seismic risk zones have not been assigned to Alaska and **Hawii.**



SOURCE *Earthquake Prediction* in *Society (SRI. Center* for Resource and Environmental Systems Studies. February 1977). p. 8.

within 210 days of enactment, and this has been done. Within 300 days of enactment, the President must designate a lead agency, assign responsibility in the program to appropriate agencies, and establish goals and target dates for the program.

A third element of the Act is a State assistance program which permits its assistance to be made availablc to the States under the Disaster Relief Act of 1974.

A fourth element is an opportunity for partic i pat ion i n the program by the appropriate representatives of State and local governments and by the public, including representatives of business and industry.

Finally, the Act requires the President to submit an annual I report on the program to Congress.

Authorizations are for three fiscal years: *1978, 1979, and 1980. The* authorizations are for general purposes, for the U.S. Geological Survey, and for the National Science Foundation. The total amounts are $56 mill ion in fiscal year 1 1978, $72 million in fiscal year 1979, and $82 million in fiscal year 1980.

THE IMPLEMENTATION PLAN

The implementation plan required by the bill provides for:

- preparations for earthquakes, including prediction, evaluation, earthquake warnings, and response planning;
- development of ways for State and local government to use information about earthquake risks in land use planning;
- development of standards and codes for earthquake-resistant construction
- examination of how earthquake hazards can be reduced through Federal construction loans and licenses;
- determination of the appropriate roles of insurance loans and relief in moderating the impact of earthquakes; and
- dissemination of information about all aspects of earthquakes.

III. Criteria for Evaluating the Implementation Plan

The purpose of the implementation plan is to provide the direction toward reduced earthquake risks.

THE PURPOSE OF THIS PAPER

This paper proposes criteria against which that implementation plan may be evaluated, in order to put into the hands of the committees of Congress a document to assist them in their own assessment.

The strategy involves identifying the issues underlying the need for new measures in earthquake hazards reduction, since the fundamental concern of Congress is conflict resolution. From these issues and associated problems, criteria for evaluating the forthcoming plan emerge. These criteria do not serve as measures in any quantitative sense; rather, they constitute elements of a standard against which the implementation plan can be evaluated.

A number of the criteria take the form of questions about the contents of the plan.

The criteria, except in certain specified cases, do not apply specifically to any one of the fields involved-for example, physical science, social science, or engineering—to the exclusion of the others. Instead, the criteria are to be used to assess how well the plan deals with all the disciplines and all the parties-at- interest.

WHAT IS A PUBLIC POLICY ISSUE?

A public policy issue may be defined as a fundamental enduring conflict, among or between objectives, goals, customs, plans, activities, or stakeholders, which is not likely to be resolved completely in favor of any polar position in that conflict. The necessarily temporary resolution of issues by a public policy is likely over long periods of time to move closer to favoring one pole over another. Thus, the crucial task facing public policy at anyy given time is to strike a fresh, workable balance among conflicting forces.

It is important to distinguish issues from prob-- lems. A problem is solved by applying knowledge and choice in a definitive way. Problems can be solved, while issues cannot.

In the policy arena, especially in Congress are few problems. Consequently, there are few opportunities for solutions, and the search for them is usual l}' sterile. For Congress the need is to identify alternatives and options and to specify their consequences, in order to facilitate the selection among them.

The fact that any significant public policy matter is an interlocking collection of subissues makes it difficult to come to grips with an issue.

The key issues are not obvious, since they usually have not been presented in a clear, cogent, or neutral way by any of the parties concerned. It is usually not in their interest to do so.

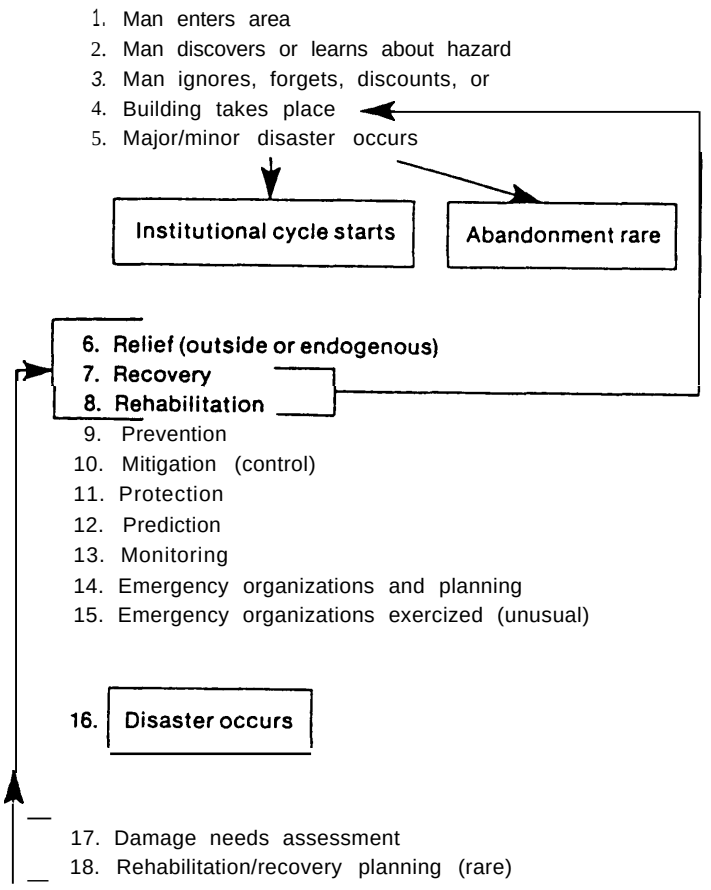
Issues are also value-laden. Since values are heterogeneous and overlapping among the parties-at-interest, it is difficult to identify and sort them into tidy bundles. An effective way to discern the values of each party in the conflict is required. That revelation is not likely to result from simple direct inquiry.

Issues call for resolution by compromise rather than a clear victory for any party in the conflict. It is through consideration of the above that issue identification becomes the central theme in determining the criteria for the evaluation of the implementation plan.

THE LIFECYCLE OF AN EARTHQUAKE HAZARD

Figure 2 presents a general picture of the lifecycle followed by all hazards, including earthquakes, as

Figure 2.— Lifecycle of a Hazard



SOURCE. Office of Technology Assessment

they evolve from the natural environmental circumstances into risks from the involvement of that environment with man's works, on through disaster and disaster recovery. This lifecycle conception complements the issues analysis strategy by presenting an overall framework which permits the identification of points of strength and weakness in current public policy.

As it stands now, the relative strong point with regard to earthquake hazards is Item 14, the emergencv organization and planning for dealing with the immediate postdisaster situation. Substantially weaker, is Item 15, the practice exercise of the emergency response capability. Item 17, the damage assessment following a disaster, is probably at a mediocre state of developmcnt with regard to a major earthquake, although in good shape with regard to a minor quake.

Seriously lacking, however, from every *sector* subject to earthquake and characteristic of most major disasters, is the rehabilitation--recovery planning that must be done well before a major disaster. This calls for elaborate and comprehensive plans facilitating relief, recovery, and rehabilitation, and rebuilding in ways that avoid repeating past errors. Building adequate structures on suitable sites provides effective long-term hazards reduction. Effective mitigation can only be pren--ised on this rehabilitation-recovery planning.

As it stands now prevention and protection measures (Items 9 and 10), through adequate construction, suitable construction codes, and retrofitting existing structures, involve major policy issues, as is discussed below.

With the development of prediction and warning capabilities in the earthquake area (Item 12), a host of social, economic, and most importantly, political problems arise as new developments in the public policy picture. Relief, recovery, and rehabilitation measures (Items 6-8) are in relatively good shape for short-term disaster relief and small disasters (less than a billion dollars damage). However, as noted above, recovery and rehabilitation planning is wholly inadequate in every earthquake disaster area in the United States today.

As it presently stands the most likely circumstance is that San Francisco, Calif., St. Louis, Mo., Salt Lake City, Utah, Los Angeles, Calif., Boston, Mass., or Charleston, S.C. would be rebuilt essentially along their present lines after a major disaster.

Therefore, the single most important public policy question with regard to earthquakes is long-term land use planning for recovery. The major short-term policy should be orchestrating public policy tools simultaneously to minimize life and property loss during a quake while sustaining orderly community growth and developmnent.

IMAGES OF THE FUTURE

Present public policy actions are unlikely to have major short-term consequences for the quality of life or the public well-being. Their major effects, both planned and unplanned, will occur in the future. Consequently, this question arises:

What are the explicit, extrapolative, and normative assumptions about the future with regard co earthquake hazard regions, technologies, public policy, population, and other variables that have entered into this plan?

Trends within the structural elements of society w.ill basically determine the future context in which present policy is implemented. Making explicit those trends and so making explicit the potential for changes, shifts, and discontinuities in those trends could be important to defining and selectin$_{g}$ among alternative policies. Trends related to earthquakes are shown in table 1. Table 2 is a list of more general trends in relation to natural hazards.

The 49 trends in table 2 fall into six groups.

. General
• Managernent
. Governmental
. Scientific and Technical
• Social
• Economic

These trends were developed from OTA staff work on the preliminar$_{y}$ analysis of natural hazards mentioned in the preface.

Table 1 .—Some Trends Related to Earthquakes

1. Population and investments are increasing in areas of high seismic risk.
2. There is a trend, particularly on the west coast. toward rehabilitation of structures in contrast to new construction. The extent to which this facilitates retrofitting for hazards reduction. the extent to which it inhibits more effective land use planning, and its general interaction with hazards mitigation merit close attention.
3. Concern over earthquakes has become intertwined with concern over powerplant, liquid natural gas facility, and other major civil and industrial works siting.
4. A functional earthquake prediction capability is increasingly likely. although it is not clear that such a capability is in any way imminent.
   A prediction capability will create new problems and new opportunities. The new problems principally deal with institutionalization of the techniques and the Identification of an appropriate management scheme to minlmlze the undesirable side effects of credible predictions.
5. There is continuing resistance to recognizing risk of major earthquakes in those areas that have not experienced quakes for many decades.
6. Knowledge related to controlling or moderating earthquakes is Increasing. While earth-quake controls-are not likely to be practical in the near future, major institutional and side effects will result from achieving and using such capabilities.
7. Several trends characteristic of hazards in general are listed here with reqard to earthquakes:
   - We have been and still are building toward huge catastrophes. These latent catastrophes could take thousands of lives and cause tens of billions of dollars In property damage.
   - Public policy continues to promote the potential for catastrophic life and property loss by permitting— i f not actually encouraging— Inappropriate development on hazardous terrain.
   - Progress is being made In dealing with earthquake hazards In a variety of legal modes. For example, the earthquake code for Long Beach. Calif, seems to be a successful application of legal measures Its degree of success in influencing actual structures is unclear
   - Land use planning integrating technical, economic, and administrative measures is on the increase, both as an aspiration and as a government function.
   - Earthquake hazards management is moving from the current high priority on relief to mitigation, prevention, and loss reduction.

SOURCE. Off Ice of Technology Assessment

Table 2.—Trends in Relation to Natural Hazards in the United States

Genera/

1. The loss of life has remained fairly stable over several decades. It is not clear to what extent this stability can be attributed to better planning, preparedness, fewer severe events, social factors, or disaster-reduction efforts. The detailed patterns in individual hazards may be different: for example, there is a weak long-term trend toward an increase in flood deaths.
2. Property loss has increased. It is not clear to what degree this reflects true increases, and to what degree the trend results from other factors, such as inflation, better reporting, and insurance availability.
3. We have been and still are building toward huge catastrophes (for instance, in coastal zones). These latent catastrophes could take thousands of lives and cause tens of billions of dollars in property damage.
4. Public policy continues to promote the potential for catastrophic life and property loss by permitting — if not actually encouraging—development on fragile, dangerous. or risky terrain. This is particularly so in flood and cart earthquake-prone areas.

Table 2.—Trends in Relation to Natural Hazards in the United States—cont.

Management of Natural Hazards

5. There has been a long-term trend toward the use of physical and technological solutions rather than institutional or social-technological solutions to hazards. One generally finds flood control, rather than land use management, as the historically preferred measure. Physical measures seem to be politically more acceptable since they may bring financial benefits and have a minor impact on short-term investments. As pointed out in the four following trends, this situation is changing.

6. There is an overall Federal shift in emphasis from structural to nonstructural prevention and protection measures.

7. There is a trend in hazards management from the current high priority on relief to mitigation, prevention, and loss reduction.

8. "Acts of God" are a decreasingly important aspect of natural hazards. The combination of prediction, control, and loss mitigation measures reduces the unanticipatable, unplanned-for elements in the "act of God. "

9. Progress is being made in dealing with natural hazards in a variety of legal modes. The earthquake code for Long Beach, Calif., and the management of the floodplain in cities, such as Hilo and Valdez, seem to be examples of successful applications of legal measures.

10. Land use planning is on the increase, both as an aspiration and as a governmental function. It is a reflection of a larger trend towards increasing awareness of the need for planning for future management. It is not clear, however, to what extent planning is being effectively reduced to management. There is a generally recognized lag between planning and its implementation and effective application.

11. The growth of future studies, forecasting, and the institutionalization of long-range planning is a trend across all sectors of society.

12. The trend is toward greater reliance on the Federal Government for long-term planning at the national level and for stimulating planning at the State and local level.

Government/

13 There is an increase throughout Government in Federal interaction and intervention with what had previously been nongovernmental or State and local concerns. This long-term societal trend is manifested in virtually every aspect of hazards, and is a partial reflection of the following three trends:

14. Cultural homogenization—the growth of a national society.

15. There is a trend toward new institutions and new institutional mechanisms for dealing with what were in the past personal, private, or nongovernmental responsibilities.

16. Bureaucratization of public and private institutions.

17. The growth of big Government continues, and cent continues to engender hostility at the State and local government level and with the general public.

18 State activism. in terms of better integration at the State level of various complex functions, growing concern about risks and hazards. and increasing animosity toward Federal Intervention are a cluster of closely related trends.

19. The trend is toward increasing layers of regulatory complexity at the State and local level, with public backlash to this trend.

20. The long-term trend toward broader public participation in governmental and private planning and decision making cuts both ways. Giving special interest groups a louder voice often has the effect of paralyzing effective longer term actions. It also tends to be litigious in its effects, thereby making definitive action difficult to take. On the other hand, participation creates the demand for more effectively engaging people in decisions.

21. There is an increasing Federal role in disaster assistance and indemnification for hazards losses, in part because of the limited resources available at individual State and local levels.

22. There is a trend toward the partial transfer of risk burden for disaster from the Federal Government to lower level jurisdictions and individuals through insurance programs and mandated land use planning.

Scientific and technical

23. Development of new prediction techniques, particularly dealing with earthquakes and weather-related phenomena such as hurricanes and tornadoes, are creating both new problems and new opportunities. The problems principally have to do with institutionalization of the techniques and the identification of an appropriate management scheme for the undesirable side effects of prediction capabilities.

24. Attempts to control natural hazards are increasing and may be expected to continue. e.g., earthquake control, hurricane modification, hail suppression, and fog dispersal. There seem to be no clear limits to the technical ability to influence weather.

Again, there are major questions about institutions and side effects that society has only begun to examine.

25. Inadvertent and uncertain modification of weather and inadvertent modification of climate are continuing trends in the United States and throughout the world. Similar trends exist for terrain both in terms of modifications of soil characteristics and of land use and water run-off patterns.

26. There is some agreement among climatologists that the climate is shifting. The direction of that shift—warmer or colder—and its relation to longer term climate shifts is unclear.

27. Nonatmospheric changes are also occurring, such as a rise in sea level.

28. Man's actions are an increasingly significant component of geophysical and environmental phenomena in the world. In some regions the generation of CO_2 exceeds the local capabilities for assimilation. Man is creating heat islands: man is affecting the albedo through deforestation.

29. There is an increasing amount of research on natural disasters and natural hazards. reflecting the generally Increasing role of research and development in the over. all socioeconomy.

Although research is increasing. there is no comprehensive or adequately coordinated hazards disaster program. The transitory interests o f funding agencies is spotted and fragmented. Acute attention to part particular disasters creates disjointed research programs. Fur-

Table 2.—Trends in Relation to Natural Hazards in the United States—cont.

thermore, the total volume of research on natural hazards from the point of view of the lifecycle of hazards continues to be very poorly funded.

30 Practical utilization of both well-established and new knowledge continues to be underplayed. The mechanisms at the Federal level for organizing, packaging, successfully delivering, and assuring utilization of knowledge at the Federal, State, and local levels continues to be fractionated, inept, and underfunded.

31 Remote sensing as a technological tool in relation to some natural hazards is now w-en developed. Application and utilization of remote sensing remain to be more effectively institutionalized.

32. The mapping and the collection of hazards-related data are increasing through the country.

Social *trends*

33 There is a growing awareness of misfires from man's actions and intervention. Hence there is a growing awareness in and out of Government of the need to attend more closely to the interaction and effects of people's activities on the environment.

34. There is a growing awareness of the interconnectedness of things. The first law of ecology ''Everything is related to everything else''—is increasingly accepted both as a fact and as an ideological position.

35. There are rising expectations in the United States of safety, security, high quality of environment, and the preservation of the highly valued assets of man and nature.

36. The growth of tourism, vacationing, travel, increased affluence, and leisure time are contributing to the development of fragile and hazardous areas.

37. An awareness of hazards is increasing at the governmental level and, to some extent, at the popular level, partially in response to recent media coverage.

This trend toward a diffuse awareness of hazards contrasts with the relative lack of awareness of the hazards, vulnerabilities, and risks in a particular locality on the part of public officials, realtors, architects, designers, and owners of property.

38. The growing demand for accountability in the expenditure of public resources, a beneficial trend in itself, may emphasize program objectives for convenience in accountability to the detriment of effective program implementation. This trend may promote increased demands for immediate and effective program implementation. It may also promote increased demands for immediate and effective response to new programs for which effective short-term responses are unrealistic.

39. There is a general increase in liability suits against architects, engineers, and other professionals involved with the design. construction, and evaluation of structures. While this Increased liability on the part of architects, for example. is creating major concerns for the profession, in the *long* run, it should, if properly orchestrated and supported by reliable information, be one key to improving hazards-resistant design and siting.

40. Urbanization, metropolitanization, and suburbanization Continue as long-term trends, with consequent stresses on land use and strong pressures to build and overbuild on hazardous ground. Continuing demographic shifts are creating special stresses on areas in the coastal zone, riverine floodplains, and other places subject to disasters. To *some extent* the continuing mobility of the population brings a constant stream of migrants who are unfamiliar with the major hazards of a particular area. Since major disasters tend to occur on decades-long cycles, they are not common topics of conversation.

41. Demographic shifts, such as the move into the sunbelt, may be creating special stresses on relatively fragile environments.

42. Such factors as: declining birth rate, shifts in rates of family formation, marriage, divorce, and women's entry into the work force affect population mobility, housing styles, and urbanization patterns. Close attention to demography should be a significant part of hazards planning at all levels of government.

Economic

43. The integration of the national economy or more properly, the national society, is interactive with many of the previously noted trends, such as mobility, cultural homogeneity, and the institutionalization of problems. The same trend works toward recognizing that what were previously seen as localized problems are actually national problems. This trend underlies the tension between the need for Federal attention to national problems and the constitutional and customary State and local responsibilities.

44. The integration of the national economy leads to interesting demographic *trends in* the corporate sector. The change from large numbers of self-owned proprietorships to nationwide corporations promotes its own mobility, not only among workers, but in corporate flexibility in regard to structures, purchases, and land use patterns. This flexibility and national perspective of corporations could be a factor in either worsening or reducing the risks from natural hazards.

The corporate trend, while important, is balanced by the fact that small business makes up 47 percent of the business portion of the gross national product and 55 percent of the nongovernmental, nonagricultural employment.

45. Subsidiary to this trend is the trend within corporations toward the leasing of land. equipment, and other elements of corporate life, which tends to reduce the equity at, and hence the affiliation to. a specific locale.

46. Inflation is affecting long-range planning by making calculations based on discount rates less certain than they were in the past.

47 Economic decisions in the United States will be increasingly driven by, and must take cognizance of. water policies. The availability of water is a limiting factor in various enterprises in many locations.

48. The structural increase in the price of energy, that is. the fundamental rise in the cost of energy, is a new basic factor in the economy. It will permeate all of the society. It may, for example, lead to an acceleration of the depredation of structures and hence promote turnover. It will almost certainly Increase the trend toward retrofitting

Table 2.—Trends in Relation to Natural Hazards in the United States—cont.

and modification for energy conservation. The opportunity to exploit this for hazards reduction merits consideration. A potential long-term decrease in the use of automobiles may effect long-term land use patterns, planning for which should take cognizance of natural hazards.	49. A trend reversal toward labor-intensive production associated with increases in costs of energy and materials might promote durability in structures and, again, be a facilitating factor in hazards control and mitigation.

SOURCE: Office of Technology Assessment.

IV. Criteria for the Evaluation

The first issues in need of resolution deal with basic policy strategies. What framework is the implementation plan trying to establish for coping with the earthquake situation? What did Congress intend by establishing this law? What are the basic assumptions about Government, science, and society from which it proceeds? Why was this Act formulated as it was, and why is it to be implemented in this way?

ISSUE 1
FEDERAL VS. STATE AND LOCAL RESPONSIBILITIES

First, the division of power and responsibility} among the various levels of Government that are or must be involved in earthquake hazards reduction must be clarified.

The Federal agency would find it most convenient if its initiatives took priority and were uniform across the country. This, however, would ignore state and local differences in awareness, perspective, extent of hazard, and competing objectives of, and differences in, distribution of power and responsibility.

Matters of disaster preparedness have traditionally been left to the individual States, with county and local emergency services (civil defense) departments doing the actual work under State office coord i nation.

State departments of geology, while usually cooperating with the U.S. Geological Survey, are wholly independent of the Federal agency and may function as subdivisions of other State agencies. Few States have statetwide planning agencies to deal with land use, social and health services, or community affairs. County, city, and regional planning agencies often function independently of (and frequently at odds with) each other. Some States have statewode building codes, while others leave code adoption and enforcement to the individual counties and ciities.

Disaster relief has been the least fragmented hazards mitigation program to affect most States. Although private relief agencies contribute extensively, the largest amounts of money come from Federal sources. Even private programs, such as the Red Cross and the Salvation Army are coordinated through the Federal Disaster Assistance Administration.

The need for a coordinating or lead agency is obvious, yet the constitutional tradition leaves as much decisionmaking power with the individual States as possible. Most communities fight bitterly against statewide or county control of their affairs. It is clear that the implementation plan must take cognizance of the need to balance these tensions in order to accomplish the objectives of the Act.

Is the emphasis to be on Federal funding of programs and projects, or are the private sector and State/local governments to be encouraged to fund programs through the use of tax incentives, matching funds, fund raising from local profitmak - ing projects, local taxes, and the like?

Questions

1. How does the plan divide power and responsibility among Federal, State, and local levels of government and the private sector? By what measures is that division likely to be effective and cost-effective?
2. Where are the primary feedback and decisionmaking functions?
3. Does the plan allow for continuous feedback and interaction among the levels of government?
4. How is the veto power and appeal-from-decision right apportioned among the three levels of government?
5. To what extent does the plan encourage local and State agencies and the private sector to go beyond Federal plans and programs?
6. How are those modifications permitted, encouraged, or discouraged?

7. Does the plan provide for local/regional bodies to request cessation of Federal programs that do not fill the needs they were initiated to fil!?

8. Does the implementation plan depend totally upon Federal funding?

9. Does the plan encourage the use of part-Federal and part-State, part-local, or part-private sector funding? What funding assumptions underlie the plan?

10. Does the plan provide for resolution of intrastate legal conflicts between counties and municipalities receiving Federal funding?

11. Does the plan provide for equitable distribution of projects between the public and private sectors?

12. Does the plan effectively induce cost-sharing betweem public and private entities?

13. Does the plan encourage local government and the private sector to explore ways of funding programs for their own communities?

14. Does the plan provide safeguards to see that projects or programs are carried out by the entities that can do the job in the most effective, efficient, and economic manner, regardless of whether they are public or private?

I 5. Does the plan provide for expansion, contraction, or modification of voluntary activities in earthquake hazards reduction?
- If so, specifically, what are these anticipated changes and on what basis have they come forth?
- Have representatives of the affected voluntary agencies been consulted?

16. There is a wide range in severity of earthquake events in many of the regions of the country. Would there be value in defining a maximum credible earthquake disaster in various cities, counties, States, or regions and using this as a framework with wihch to plan public policy?

17. How will the plan go beyond the hortatory in informing, motivating, and activating flexible State and local actions?

ISSUE 2
EARTHQUAKES VS. AN ALL NATURAL HAZARDS STRATEGY

While it may be convenient for researchers and the large Federal agencies to handie hazards individually, the practicalities of State and local government organization and functions increasingly require integrated planning and operations for all hazards.

Earthquakes are only one of a number of natural hazards to which people and property are exposed. Some of the secondary hazards of seismic activity are also common to ocher disasters. In some cases, the adjustments to other hazards may be inappropriate for earthquakes and versa. However, money that is spent in the same way to reduce several kinds of hazards is wasted in duplication. Wherever possible, the implementation plan should seek to prevent duplication of funds and effort, while adhering to the desire of Congress to reduce the hazards from earthquakes.

Questions

1. How does the plan coordinate, or conflict with, other hazards reduction programs now in effect, needed, or planned?

2. Does the plan allow for flexibility in giving research grants and planning funds, in order to meet the needs for reduction of allied hazards?

3. Does the plan encourage consultation with researchers and planners working in other hazards reduction fields, to see where duplication can be avoided?

4. Does the plan allow for consolidation with other hazards reduction programs at the State and local levels?

5. To what extent can the earthquake plan become a part of-or the basis for-a program for managing all natural hazards?

6. As a result of subsea earthquakes, tsunami are a particulary important problem in the coastal States of the United States. How will tsunami research be related to earthquake research ? What relative importance is given to tsunami? On what basis?

7. Table 3 lists crier a hundred instruments of Government that could be a part of an orchestrated Fink-al approach to hazards mitigation. Which instruments from this or similar lists have been selected as part of the plan's activities and which have been rejected or deferred? By what criteria?

8. Will the plan overwhelm the research and operational systems for all other hazards with its emphasis on earthquake planning, organization, and research, etc. ?

9. Table 4 suggests specific earthquake risk mitigation measures tailored to various types of earthquake warning. To what extent are considerate ions of this sort integrated into the plan?

ISSUE 3
NARROWING CHOICES VS. WIDENING CHOICES: THE ACQUISITION OF INFORMATION

There are three information areas with which the implementation plan should be concerned: accuracy and adequacy of past information from which certain assumptions have been made, adequacy of current information necessary for program planning, and decisions on what information should be sought in further research.

Quality of Existing Information

Theories about the behavior of faults, of structures, and of people have been constructed from historical information, some of it quite recent. If the quality of that data is poor, then the assumptions based on that data may prove false and, in turn, action based on those assumptions may be a waste of money and effort. Such actions may even endanger lives and property by creating a false sense of security.

1. Does the plan depend upon acceptance of particular theories of geophysical, structural, or human behavior to the extent that contradictory evidence would seriously impair the usefulness of the plan for reducing earthquake hazards?

2. Have these basic assumptions about behavior of the Earth, of structures, and of human beings been subjected to rigorous professional criticism of the highest quality?

3. Do a majority of researchers in the appropriate fields of geophysics, geology, engineering, and social science support those assumptions on which planning and programs will be based?

4. Several developed nations, notably Italy and Japan, have a significant history of earthquakes. In the densely populated regions of Japan, extensive measures have been taken for earthquake prediction, mitigation, control, disaster response, and so on. What mechanisms have disclosed and will disclose such experience systematically? In terms of the present plan, to what extent has such information been used in planning?

Adequacy of Current Information

Successful execution of the implementation plan will depend upon coordination of myriad State, Federal, and local laws related directly or indirectly to earthquake hazards reduction. Conflict could easily arise between earthquake programs and flood control, environmental policy, historical preservation, building codes, and land use planning policies.

Knowledge of the existing "pool" of qualified professionals in hazards management is necessary to assign personnel for projects and programs requiring their expertise.

1. Does the plan provide for a clearinghouse (or regional clearinghouse) for information on State, Federal, and local laws that will affect or be affected by it?

2. Does the plan provide for resolution of legal conflicts, on the Federal, State, and local levels?

3. Does the plan provide for a personnel data clearinghouse (on at least statewide basis) so that programs and projects can be staffed by qualified persons and future personnel needs can be estimated?

4. How will the plan meet needs for reliable certified information in a timely fashion?

5. Does the plan provide for a broad, critical inventory of earthquake-related information relevant to private sector groups and individuals?

Table 3.—Instruments of Government

Information Related	Financial Measures	Measures	Operation	Policy-Related Function
Generation of information by means of: data collection, e.g., census surveys demonstration evaluations technology assessment public (e.g., congressional) hearings monitoring research and development on (a) social costs (b) public policy alternatives (c) the system (d) technology (e) basic science (f) intervention experiments The packaging of information: as by curriculum development definition of costs display of pros and cons The dissemination of information in terms of: reports seminars extension programs trade fairs conferences, symposia State technical services press releases and public information Stimulation of discussion, interest, concern by: providing a forum education publicity propaganda Withhold information Proposing model legislation	Taxes Residual charges Value added tax Excise tax Income tax Corporate tax Personal tax Customs duty Tax write-offs Tax deferment or abatement Subsidies Depreciation and depletion Allowances Grants Contracts Loans Rewards for innovation and invention Incentives, e.g., matching funds, scholarships, loans, grants, forgiveness of loans in return for special services, contests Earmarking funds, setting floors and ceilings Insure loans, crops, investments, etc. Compensate for loss Underwrite Set priorities on funding Allocate funds	Regulate/deregulate Legislate Set standards Certify License Codes Government control or monopoly Grant rights Form interstate compacts or special legal units Court decisions, injunctions, etc. Cease and desist orders Monopoly privileges Inspection requirements Fines and punitive damages Registration and mandatory reporting Audit Mandamus (a writ from a court ordering a lower court or public official to do some specified thing) Substitute criminal for civil sanctions or vice versa Institutionalize Rationing Quotas Limit Liability Import Export Copyrights Patents Prohibitions Ban Moratoria Require warranties Zone Eminent domain (the power of the State to take private property for public use with payment and compensation to the owner) Seize Occupy Declare martial law	Building civil works Build facilities: drug treatment centers sewage disposal plants Operate facilities: traffic (air, sea, and auto) control systems Reclaim land Establishment or support an industrial base by Government purchase Institutionalize, R & D, Government departments, semi-public corporations, and establishing new institutions Demonstrate	Setting of policy Defining priorities Set objectives import/export goals Delayed decisions Coordinate affairs

SOURCE: Joseph F. Coates, "What is a Public Policy Issue?" in *Judgment and Decision in Public Policy Formation*, Kenneth R. Hammond, Editor, pp. 33-69, Westview Press, Boulder, Col. 1978.

Table 4.— Earthquake-Risk Mitigation Measures

Earthquake-risk mitigation measures are chosen because an individual, an institution, or society wants to reduce losses from an earthquake. Mitigation measures are taken for the overall benefit of the social level (National. State, or regional) adopting them. For example. i f the State takes mitigation measures it will evaluate them in terms of costs and benefits to the entire State. The measures that are available for reducing the risks of earthquakes can generally be classified as follows:

- earthquake engineering.
- seismic zoning.
- disaster preparedness. and
- disaster relief and insurance.

Earthquake engineering and seismic zoning reduce the vulnerability of the built environment to the effects of the earthquake. Disaster preparedness prepares individuals or groups to deal with the effects of the earthquake on people. Disaster relief and insurance spread the financial losses incurred as a result of an earthquake to a larger segment of the society. Because the first three measures operate before an earthquake. they are directly related to the characteristics of an earthquake prediction. The last two measures interact with earthquake prediction in more indirect ways. Al l of these measures, however, can be taken i n the absence of an earthquake prediction. This raises the question of whether earthquake prediction is a necessary or useful adjunct to the application of these measures.

The selection of the mitigation measure is governed by the leadtime provided by a prediction. Consequently, knowledge of the time required for the effective implementation of each mitigation measure is essential:

- Earthquake *Engineering.* As earthquake engineering criteria might be applied to new structures, it will take many decades to significantly affect the earthquake resistance of the structural inventory in a region. However. in terms of strengthening existing structures and otherwise reducing their vulnerability much less time is required and the limiting constraint in many cases could become skilled manpower and resources.
- Seismic Zoning. As seismic zoning might be applied i n a normal environment. It too could take a long time to significantly reduce the seismic vulnerability of a region. In the long term. as higher risk structures in a Potentially vulnerable region reached the end of their economic lifetime only certain uses of the land would be allowed: for example. warehouses would replace office buildings. parks would replace homes. and in unbuilt areas only certain uses o f the land would be allowed as the region expanded. However. in a short-term emergency situation prompted by an earthquake prediction, designated areas or structures could be temporarily abandoned.
- *Disaster Preparedness.* Some disaster preparedness activities (e. g . evacuation) can be carried out with even a minimum warning leadtime. but some readiness measures cannot be maintained indefinitely. There IS probably an ideal leadtime for disaster preparedness that permits the achievement of an optimal posture for a given threat but IS not so long that the posture becomes burden some
- *Disaster Relief and Insurance* Private disaster insurance will pro probably not be available after an earthquake prediction However. for the relatively long period bebetween predictions of damaging earthquakes. It could again be made available. The question then becomes whether or not enough persons can be motivated to purchase it. Public disaster relief can become a substitute for private disaster Insurance. but public disaster relief is not sensitive to the warning period except to the extent that preparatory actions may be required as a condition of compensation for loss

Tailoring Mitigation Measures to Earthquake Warnings

A planning and operations guide could be developed to Identify measures to be taken for various types of warning (short term v. long term) in places outside and Inside the predicted damage area. The guide could be prepared and periodically updated as earthquake prediction is Improved and as changes occur in enabling legislation and other factors that influence the preparedness program. I f and when a damaging earthquake is predicted. appropriate guidance could be given to the concerned agencies as part of the warning process.

Case 1: Short-Term Warning

The first situation for which guidance could be prepared is that resulting from the prediction that a damaging earthquake will occur within a period of days. During such a period. it would be too late for preparedness measures that require a long leadtime. The recommended actions that might be included in a warning to communities within the predicted damage area are the following:

Short-Term Warning: Damaging Earthquake Probable
(Risk areas specified. time insufficient for extensive preparedness measuresl

Broadcast public information and advice for this situation:

- Order evacuation of known hazardous structures and restrict access to known hazardous locations:
- Advise public and private organizations to tie down equipment for security against shock or displacement and protect shelf items from falling;
- Urge public through all mass media to make final preparations without delay (e. g., cleaning up trash or filling water containers): advise them to stay out of specified areas and specific types of structures:
- Disseminate through mass media information on fire prevention, self-help firefighting, and medical self-help;
- Order shutdown of hazardous industrial operations:
- Direct operating departments to suspend all nonemergency functions, alert personnel. check equipment and supplies, and prepare for deployment of forces if ordered;
- Mobilize all available organized forces and deploy to preassigned emergency duty stat ions:
- Fully man all control centers and establish 24-hour operations;
- Establish and maintain communications with other jurisdictions and service facilities:
- Activate staging areas and make final preparations there:
- Take actions to ensure the safety of institutionalized persons:
- Discontinue all elective surgery, release all hospital patients except those who are critically ill. and take other actions to expand bed capacity and to protect remaining patients;
- Deploy assigned personnel, equipment. and supplies to designated staging areas:
- Advise utilities and industry to shutdown nonessential services throughout the emergency area,
- Deploy field units and maintain them on standby so that they can rapidly survey area for damage and other earthquake-induced problems:
- Move firefighting and other emergency equipment and supplies outside the stations: and
- Deploy engineering and other equipment.

Table 4.—Earthquake- Risk Mitigation Measures —cont.

Case 3: Long-Term Warning

The second situation for which guidance could be prepared IS a longer prediction that provides sufficient time to Implement measures to reduce seismic risk and substantially improve capability for disaster operations. The general character of the emergency measures that might be recommended in an initial warning to threatened communities is indicated below. The specific measures would depend on the nature of the prediction (weeks, months, years) and the characteristics of the threatened community.

Long-Term Warning: Damaging Earthquake Highly Likely
(Risk areas specified. time sufficient for preparedness measures)

Establish public policy for long-term situation.

Brief key Government and non. Government officials on situation and basic emergency plan and earthquake response plan.

Review. update, or. if necessary, develop listed items:

- Legislation and local ordinances dealing with this type of situation:
- Organization and assignment of responsibility to emergency service units:
- Mutual aid agreements with other local jurisdictions and State agencies:
- Plans for informing the public during emergencies:
- Preparedness plans for hospitals, other institutions, and organizations that operate essential utilities (power. water, natural gas. sanitation. communications, and transportation. including food and fuel distribution):
- Staffing and operation of emergency operating center and other headquarters; communications with emergency service units and with other localities;
- Maps indicating risk areas— fires. potential dam flood areas, landslides, structures that are susceptible to damage. etc.: and
- Procedures for determining (1) distribution of earthquake damage and ensuing hazards and (2) postearthquake capability of hospitals, water systems, and other vital facilities and services.

Conduct planning workshops for each service. Review checklist of postearthquake actions:

- Prepare instructions for service units and personnel, assign responsibility for specified actions. and indicate when, where. how, and with what resources the actions are to be accomplished. and by whom:
- Evaluate existing capability for performing the listed actions and where appropriate identify measures and resources that would improve capability;
- Identify measures that will reduce cart earthquake losses:
- Determine what normal activities and services could be deferred or curtailed to free funds for emergency preparations:
- Develop detailed plans for actions to be taken if a short-term warning is issued: and
- Determine requirements and prepare standby procurement orders for needed equipment and supplies.

Identify and mark hazardous structures and locations in the risk area. Consider actions to reduce risk (e. g.. removal. strengthening, prohibit of of occupancy).

Expand fire prevention programs and abate fire hazards:

- Augment firefighting resources: prepare mobilization instructions: and
- Survey community for current fire risk. modifying or confirming fire contingency plans as appropriate.

Begin actions to expand cadre and Improve capability of emergency operations:

- Recruit, train, and assign personnel as needed to increase service capabilities for rescue, first aid, firefighting, fire prevention. sanitation, etc.;
- Prepare mobilization instruction:
- Bring emergency operating center and other headquarters to full readiness: provide for auxiliary power and augment communications:
- Arrange for use of facilities selected for staging area. mass care. and other purposes. and prepare them for use: and
- Procure previous identified needed equipment and supplies.

Improve readiness in potential dam flood areas:

- Complete evacuation plans. warning system:
- Transfer key facilities:

Ž Develop engineering procedures to determine damage: and

- Consider lowering water level.

Improve readiness and capability of lifeline organizations, resource agencies, essential industries

- Identify measures to reduce earthquake losses and disruption of services:
- Activate standby agreements for transportation and other lifeline services:
- Activate standby agreements for utilization of commercial and educational facilities: and
- Consider moving up resources from locations outside the risk area.

Improve readiness and capability of hospitals. medical and allied professionals, and public health agencies:

- Prepare Instructions for mobilizing personnel and resources:
- Expand stocks of drugs. medicines, and sanitation supplies:
- Check readiness of hospitals to discharge or move patients and expand bed capacity. consider deferring elective surgery; and

. If appropriate, begin moving in resources from locations outside risk area.

SOURCE Leo W. Weisbecker and Ward C. Stoneman. *Earthquake Prediction* in *Society,* **Center for** Resource and Environmental Systems Studies, SRI Internatlonal February 1977 p 8

Providing for Future Information

There is great need for more research into all the problems associated with earthquakes. Every effort should be made to channel newly authorized funds toward research that has practical application to the earthquake problem.

New problems, such as those arising from new technologies, may require innovative approaches and creative solutions. Established bureaucracies, however, tend to restrict funding to "tried and true" methods. While any reliable methodology must be based on logic and clear reasoning, there is ample room for new ways to reconcile the conflicts between bureaucratically "safe" approaches and creative research.

Future needs for professional personnel in geophysicalgeotechnical, engineering, architcc--ture, planning, emergency preparedness, and many other related fields must be ascertained and plans made so that an adequate number of persons can be trained. Quality control standards must be set for future research, so that the information gathered can be used successfully for reduction of earthquake hazards.

1. Does the plan tend to emphasize new research at the expense of action on research already completed?
2. Does the plan tend to emphasize action in areas where more or better quality research is needed in order to determine the correct form such action should take?
3. Does the plan encourage practical research rather than esoteric projects that enhance the researcher's professional or academic status?
4. Does the plan provide for rigorous evaluation of future research proposals and monitoring of research in progress to assure high-quality projects?
5. How will a systematic, flexible, useful research and development program be established? How will it be managed and coordinated? What specific measures will be taken to feed information to all interested parties and to withdraw from them information about utility, new needs, etc.?
6. Does the plan provide for assessment of future personnel needs?
7. Does the plan provide for educating future personnel in the appropriate fields.'
8. Does the plan encourage colleges and universities to offer appropriate courses for persons entering disaster-related fields or to other professionals indirectly involved with disaster mitigation?

ISSUE 4
NARROWING CHOICES VS. WIDENING CHOICES: THE ROLE OF DISSEMINATION AND UTILIZATION OF KNOWLEDGE

Another basic imbalance lies between legislative or regulator}' imposition of solutions and the dissemination of needed information to local and State entities, which can then use the information to work out the alternatives and influence selection among themselves.

A mechanism by which users and their partic--ular needs can be identified is needed. While there is, on one hand, much usable data from prior research that is not being put to use, action sometimes occurs prematurely in areas where more or better quality research could lead to more rational and effective solutions.

The citizen who wants to be involved in local planning and decisionmaking also needs good in--formation keyed to the nonspecialist. Here the Federal specialist can prove invaluable as advisor and information source. Citizens may not reach the same conclusions as the experts, hut, unless their decisions are blatantly inhumane or unlawful, they have the right to determine their community's destiny.

Questions

1. Does the plan concentrate on problems rather than issues?
2. How does the plan provide for the timely dissemination of information to the appropriate users, in a form that can be readily utilized?
3. Does the plan encourage centralized funds, research, and efforts in a few agencies or geographical areas or decentralized organi-

zation among a large number of agencies, institutions, and researchers?

1. Does the plan encourage agencies and institutions to act autonomously, or does it confine individual agencies and institutions to restricted areas of research and program development?

5. Is there a mechanism for timely and effective feedback?

6. By what means, based on what principles, will the division of responsibility for information dissemination be made?

7. Does the plan encourage citizen participation in program planning and decisionmaking through the usual channels of public meetings, hearings, and the like?

8. Does the plan tend to impose decisions of "outside experts" on communities regardless of the wishes of those communities? When is that justified? Not justified?

9. Does the plan encourage external Federal or State controls at the expense of informed consensus?

10. How will utilization objectives be determined, promulgated, and evaluated?

11. If a community, county, or State chooses to make what outsiders would consider a poor public policy decision about hazards mitigation, that is, one which encourages the unnecessary loss of lives or property, what is the appropriate Federal role with regard to such decisions before and subsequent to a disaster? Does the answer depend on the size of population or property at risk?

ISSUE 5
ENGINEERING DESIGN VS. SOCIOECONOMIC STRATEGIES

Because they behave in a logical, consistent, predictable manner, yield easily quantifiable data, and perform their tasks unaffected by emotions or value judgments, mechanical devices and engineered structures tend to appeal to public officials and other decision makers.

Social scientists, planners, and public officials often rely on computer modeling for allocating human, economic, and natural resources, These models make use of assumptions, which-though easily quantifiable—may bear so little resemblance to the true local situation that they hinder or prevent effective decision making.

However, effective community decisionmaking requires that community experience and values be applied to problem solving through management of human systems, i.e., social, economic, legal, and political.

A historical example of the contlict between the engineering and management approaches can be found in changing attitudes toward adjustments to flood hazards, where dam building is being supplanted by insurance and land management strategies.

Questions

1. To what extent does the plan attempt to coordinate with or utilize other Federal statutes to enhance its objectives? Many statutes other than those containing or authorizing hazards reduction programs could be utilized for hazards management, for example, statutes dealing with land management, loan provisions, licensing requirements, etc.

2. How will engineering design measures and techniques be assessed and integrated with socioeconomic strategies? Does the plan view them as complementary?

3. What is the plan's approach to the role of remote sensing as a planning aid?

4. Does the plan provide for equitable distribution of funds, at both the research and applications levels, between engineering design measures or techniques and strategies for the management of human systems?

5. Does the plan encourage comprehensive, coordinated, long-range planning for disaster research and program development by social agencies and financial institutions?

6. Does the plan encourage State, regional, and local planning agencies to develop

comprehensive hazards-reduction and disaster programs?

7. Does the plan encourage the use of ready-made "canned" computer technology in place of the judgment of community decisionmakers? How will balance be achieved?

S. Is the plan likely to result in attempts to fit the community to the program instead of the program to the needs of the community?

ISSUE 6
LIFE SAFETY VS. PROPERTY VALUE-ORIENTED PROGRAMS: BALANCING NEEDS

It is accepted that no implementation plan would be written deliberately to place 1 lives in jeopardy or to protect one group at the expense of others. However, it is quite possible that the ultimate effect of certain procedures, regulations, or policies may be just that.

The welfare of the community-at-large needs to be considered along with the desires of particular publics. One person may belong to several publics, i.e., taxpayers, parents, union members, etc. Neighborhoods, socioeconomic classes, ethnic groups, hospital patients, senior citizens, bureaucrats, and others all constitute publics. The conflicts between the desires and needs of particular publics and the greater good of the community--at-large must be resell'ed if the applicable parts of the implementation plan are to find acceptance at the community level.

When planning only emphasizes preventing death and injury, there is a tendency to take only those minimum measures that protect 1 life, rather than to look beyond the minimum in order to protect economic investments that may be needed to restore social and economic health to the community after the quake.

Questions

1. Does the plan emphasize saving lives in contrast to protecting property?

2. Does the plan recognize that the needs and desires of the community may work to the detriment of one or more particular publics? How will these conflicts be probed?

3. Does the plan have the ultimate effect of treating some classes or groups as more expendable than others? Why? Why not? By what logic? Do these criteria shift, depending on the size of the potential disaster or the size of the comminity?

4. Does the plan contain adequate provisions for the resolution of intracommunity conflicts among property values, historical or esthetic values, and the life and health of human beings?

5. Does the plan provide recognition of certain key industries or businesses whose continued function is vital to the socio-economic health of the community, region, or Nation ?

6, How will the new law assure adequate funding and "clout" for agencies responsible for code implementation, planning, and management?

ISSUE 7
LIFE SAFETY VS. PROPERTY VALUE-ORIENTED PROGRAMS: HAZARDOUS BUILDINGS

The greatest single life-threatenin, earthquake hazard, and the one most difficult to alleviate, is the unreinforced masonry building.

In quake-prone cities, there are hundreds of thousands of these potential cleat deathtraps. Their collapse also could create debris barriers chat firefighters and emergency rescue vehicles could not pass.

Yet, these buildings represent sizable real estate investments, often by owners unable or unwilling to finance their retrofit or replacement. They are homes to those who lack the monev and/or the desire to live elsewhere. Some of these buildings have historic and esthetic value to communities which wish to preserve them, but which lack the means to bring them "up to code."

These buildings constitute a hazard too great to be ignored, but too expensive for individual owners or communities to alleviate.

Within buildings, repairable damage to nonstructural components usually constitutes more

than 50 percent of total earthquake damage and is a major life safety risk; present building codes generally are silent with regard to the selection and installation of nonstructural components in potentially seismic areas, especially so for small buildings that comprise the bulk of potential loss exposures.

1. Does the plan directly, or by some clear process, address the full range of social, economic, legal, political, and technical questions involved in decisions concerning the retrofitting or razing of hazardous buildings?
2. Does the plan consider sources of funding for reinforcing public buildings and other structures, where it is feasible, and the key relationships of other agencies, such as Federal Housing Administration (FHA), Federal Home Loan Bank Board (FHLBB), Occupational Safety and Health Administration (OSHA), etc., in this objective?
3. How can a sufficient number of qualified and adequately paid inspectors be maintained to supervise the retrofitting of old buildings or the implementation of new, upgraded seismic safety standards in new ones?

ISSUE 8
FEDERAL REGULATIONS OVERRIDING CONFLICTING STATE LAWS VS. STATE-BY-STATE RESOLUTION: BUILDING CODES

Building codes are the single most important direct way to mitigate earthquake hazards.

Some States have statewide building codes, others leave code adoption and enforcement to the individual counties and cities, some of which have no building codes at all. Much emphasis has been placed on the supporting structure of buildings, neglecting nonstructural components. There is a pressing need for more attention to code and design requirements for nonstructural elements, especially "lifeline systems," i.e., essential public Service delivery systems, such as transportation, communications, and utilities.

Building codes, whatever their emphases, tend toward only minimum 1 life safety standards, Mistalemly, public decisionmakers and their constituents often believe that the codes are all-inclusive and all-protective. The timelag between technological developments and their inclusion in the codes is often very great. Even when new developments are incorporated into the Uniform Building Code, few States require that local jurisdictions update their versions of the code.

Decisionmakers often refuse to adopt seismic hazards laws because they feel that the building code is sufficient protection. Yet, buildings constructed "to code" can suffer and have suffered partial or even total collapse.

1. Does the plan address the entire process and practice of building code formulation, revision, and enforcement?
2. How does the plan propose to meet the need for better quality, more realistic, and more cost-effective building standards?
3. How does the plan address the problem of assuring local code adoption? How will the plan utilize Federal instruments of Government to promote the adoption and enforcement of improved codes?

ISSUE 9
PREDICTION VS. PRESENT CAPABILITIES

Reasonably accurate and useful means of earthquake prediction may not lie far in the future. However, it is unlikely that reliable prediction technology will have arrived by the time the initial appropriation for Public Law 95- 124 expires, In addition, prediction methods that work in one geophysical province may not work in another. It is necessary that the plan for the wise use of earthquake prediction, but this must not be emphasized to the degree that it blinds us to the present problems what to do until we can make reliable predictions.

The plan must resolve the tension between the questions of developing future prediction capability with the problems of dealing with quakes here and now.

Figures 3, 4, 5, and 6 present basic background information on measuring earthquakes and on the technology for predicting earthquakes. Earthquake modification and control are even further away than prediction, and they will

Figure 3.— Measuring Earthquakes

The size of an earthquake is measured in terms of magnitude and intensity by two rather complex scales. The most fundamental and scientific unit of measurement is the earthquake's magnitude, a measure proportional to the logarithm of the total energy released by the event. The most common measure is the Richter scale, which is based on measurements of seismograph records scaled to a distance of 100 km (62 miles) from the center of surface energy release (epicenter) by the shock. Since the distance from an earthquake epicenter to any one of many seismic recording stations is never exactly 62 miles, tables are used to convert the seismograph records into a scale from 1 to 9.

The logarithmic feature of the scale means that an increase in magnitude of 1.0 corresponds to a tenfold increase in vibrational amplitude and an increase in energy released of about 31.5 times. Earthquakes whose magnitudes are less than 4.0 are not usually damaging. An earthquake whose magnitude is at least 7.9 is conventionally called a great earthquake. The largest magnitude ever recorded was about 8.9 in the case of two earthquakes in the Pacific: the great 1906 San Francisco earthquake had a magnitude of about 8.25.

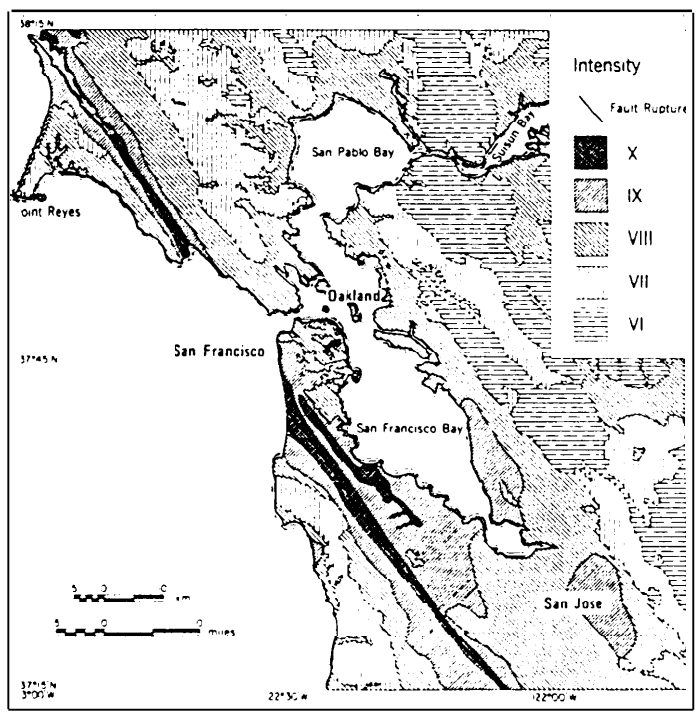
Earthquakes of the same magnitude (energy release) can cause vastly different consequences in different regions. This results partly because of different seismological/geological conditions and partly because of different structural practices. Therefore magnitude has a specific scientific meaning, but unless it is translated into specific effects to structures at given locations it has little sociocultural utility. However, the translation requires detailed knowledge of the tectonic/seismological characteristics of the source fault rupture, the transmission path source to site seismol. ogy/geology, the engineering geology and soils characteristics of the site of interest, and the foundation and structural design characteristics of the structure itself. This is a complex and expensive undertaking in either a retrospective or predictive model. There is uncertainty in this process because of the manner in which limited specific measurement of relevant properties are assumed to be representative and because of simplifying assumptions (or limits to our understanding of) important relationships.

Intensity scales have been contrived to measure the effects rather than the energy release of an earthquake. It is through a knowledge of energy release and site-specific intensities of past events that reasonable projections of the site-specific consequences of similar future events can be made. Through a careful definition of structural characteristics and observable effects. the uncertainty of the subjective interpretation of effects that define intensity is reduced to a minimum. Although there are several scales, the Modified Mercalli (MM) intensity scale is the one most commonly used in the United States. The MM scale employs Roman numerals from I to X11, each number corresponding to descriptions of earthquake damage and other effects. Because the damage and ground effects are influenced by numerous factors—such as distance from the causative fault, local geology, ground and soil conditions, and accuracy of personal observations— reported intensities can vary substantially from site to site. Thus an earthquake cannot be assigned a single intensity number. Rather, earthquake intensities observed at various locations are plotted on an intensity or isoseismal map.

Because the MM intensity scale and the Richter magnitude scale measure basically different parameters, they cannot easily be directly compared. **However, the relationship** between the two measures **for ordinary ground conditions** in metropolitan centers in California can be gauged from the following intensity map:

The Intensity Map for the San Francisco Bay Area 1906 Earthquake
(Intensities depend on distance from fault breakage and type of soil.)

Magnitude (Richter)	Intensity (MM)	Damage
1	I	Observed only instrumentally
2	I-II	Can be barely felt near epicenter
3	III	Barely felt. no damage reported
4	V	**Felt a few** miles from epicenter
5	V1-vll	Causes damage
6	VII-VIII	Moderately destructive: some severe damage
7	lX-X	Major, destructive earthquake
8	Xl	Great earthquake



SOURCE: Leo W Weilbecker and Ward C Stoneman, *Earthquake Prediction in Society,* **Center for Resource and Environmental Systems** Studies SRI International February 1977 p. 10

Figure 4.— Modified Mercalli Intensity Scale of 1931

To eliminate many verbal repetitions in the original scale. the following convention has been adopted. Each effect is named at that level of intensity at which it first appears frequently and characteristically. Each effect may be found less strongly, or in fewer instances, at the next lower grade of intensity: more strongly or more often at the next higher grade. A few effects are named at two successive levels to indicate a more gradual increase.

Masonry A, B, C, D. To avoid ambiguity of language, the quality of masonry, brick or otherwise, is specified by the following lettering (which has no connection with the conventional class A, B, C construction).

Masonry A. Good workmanship, mortar, and design; reinforced, especially laterally, and bound together by using steel, concrete, etc.; designed to resist lateral forces.

Masonry El. Good workmanship and mortar; reinforced, but not designed in detail to resist lateral forces.

Masonry C. Ordinary workmanship and mortar: no extreme weaknesses like failing to tie in at corners, but neither reinforced nor designed against horizontal forces.

Masonry D. Weak materials, such as adobe: poor mortar: low standards of workmanship; weak horizontally.

i. Not felt. Marginal and long-period effects of large earthquakes.

Il. Felt by persons at rest, on upper floors, or favorably placed.

ill. Felt indoors. Hanging objects swing. Vibration like passing of light trucks. Duration may be estimated. May not be recognized **as** an earthquake.

IV. Hanging objects swing. Vibration like passing of heavy trucks; or sensation of a jolt like a heavy bail striking the walls. Standing motor cars rock. Windows, dishes, doors rattle. Glasses clink. Crockery clashes. In the upper range of 4 wooden walls and frames creak.

V. Felt outdoors; direction estimated. Sleepers wakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Doors swing, close, open. Shutters, pictures move. Pendulum clocks stop, start, change rate.

VI. Felt by ail. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware, broken. Knickknacks, books, etc., off shelves. Pictures off walls. Furniture moved or overturned. Weak plaster and masonry D cracked. Small bells ring (church, school). Trees, bushes shaken (visibly, or heard to rustle—CFR).

VII. Difficult to stand. Noticed by drivers of motor cars. Hanging objects quiver. Furniture broken. Damage to masonry 0, including cracks. Weak chimneys broken at roof line. Fall of plaster, loose bricks, stones, tiles, cornices (also unbraced parapets and architectural ornaments—CFR). Some cracks in masonry C. Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Concrete irrigation ditches damaged.

VIII. Steering of motor cars affected. Damage to masonry C; partial collapse. Some damage to masonry B; none to masonry A. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes.

IX. General panic. Masonry D destroyed; masonry C heavily damaged, sometimes with complete collapse; masonry B seriously damaged. (General damage to foundations—CFR). Frame structures, if not bolted, shifted off foundations. Frames racked. Serious damge to reservoirs. Underground pipes broken. Conspicuous cracks in ground. In alluviated areas sand and mud ejected, earthquake fountains, sand craters.

x, Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Large landslides, Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly.

xl. Rails bent greatly. Underground pipelines completely out of service.

X11. Damage nearly total. Large rock masses disc) laced. Lines of sight and level distorted. Objects thrown into the air.

SOURCE: Leo W Weisbecker and Ward C Stoneman. *Earthquake Prediction in Society,* **Center** for Resource and Environmental Systems Studies SRI International February 1977, p, 11

bring a whole new set of problems, including questions of international liability.

A great deal of emphasis has been placed on the negative consequences of earthquake prediction. However, there are no U.S. studies vet published that have actually measured or evaluated responses to a long-term disaster prediction. Some studies have been attempted, but i n the opinion of most social science researchers. it is risky to depend upon people's opinions of what they will do in a given situation rather than what they do when the situation becomes a reality. Some studies of actual prediction experience in Japan are being published in a volume edited by Professor Quarantelli (Ohio State University).

A study of reactions to a long-term prediction of the eruption of Mauna Loa and a short-term volcanic hazards advisory at Mount Baker, Wash., was conducted by Marts, Sharp, and Hedge (University of Washington). [1]

In contrast, there is a large body of literature on human reaction to threatening information

[1] Marion E. **Marts, David Hodge,** Virginia Sharp, Janet Cullen, et al., Social Implications of Volcano Hazard, Case Studies in the Washington Cascades and Hawaii (two **volumes). Univ. of** Washington, July 31, 1978.

Figure 5.—The Developing Technology of Earthquake Prediction

The factors most crucial to the development of practical earthquake prediction technology are the following:

- A well-deployed and varied instrumental network (see drawing).
- An active program of laboratory experimentation and simulation of rock behavior u rider stress.
- Computation facilities adequate for processing instrumental data and for extensive modeling of crystal rock behavior under stress.
- Theoretical studies for interpretation of analytical results based on field measurements and for integration of these results into existing theories and models.

Features of an Operational Earthquake-Prediction System

The form of an operational earthquake-prediction system is not yet known, but one possible type can be visualized as consisting of arrays of geographically dispersed instruments that are linked to a data-processing system through a telecommunications system. Such a system could even be incorporated into a public utility such as the telephone system. An operational earthquake-prediction system would consist of the following elements:

. Arrays of instrumentation requiring some kind of land acquisition or use rights.
- Field stations to make some periodic measurements and to provide maintenance and calibration of in-place instruments.
- Data-processing systems to reduce the field data on a real-time or near-real-time batch basis.
- Central control, probably incorporating not only the data-processing system but also the operational control and evaluation functions.

Example of Public Information Component of Earthquake Prediction

Leadtime[a]	6
Time window[b] (weeks)	3
Epicenter or region of	San Juan Bautista to Los Gates along the San Andreas Fault
Magnitude (Richter)	7.0-7.2
Confidence that event will occur[c]	85
Contingent effects	Possible 8.3 Richter magnitude along entire "locked" San Francisco Bay section of the San Andreas Fault (no confidence judgment possible)

aThe leadtime of an earthquake Prediction IS the anticipated elapsed time between the prediction and the most likely **OCCUrence of the** earthquake
The time window of the prediction IS the time period within which the event IS predicted **to occur.**
CThe confidence that the event will occuur, or probability represents a complex problem of Interpretation. **Any early probability statements are actually an indication** of what IS not known about the processes that generate earthquakes. rather than what can be expected in a new situation as a result of past experience in similar situations. However. when a track record IS accumulated the statements can be based on past experience

SOURCE. Leo W. Weisbecker and Ward C Stoneman. *Earthquake Prediction Ii Society.* Center for Resource and Environmental Systems **Studies** SRI International February 1977, p. 12

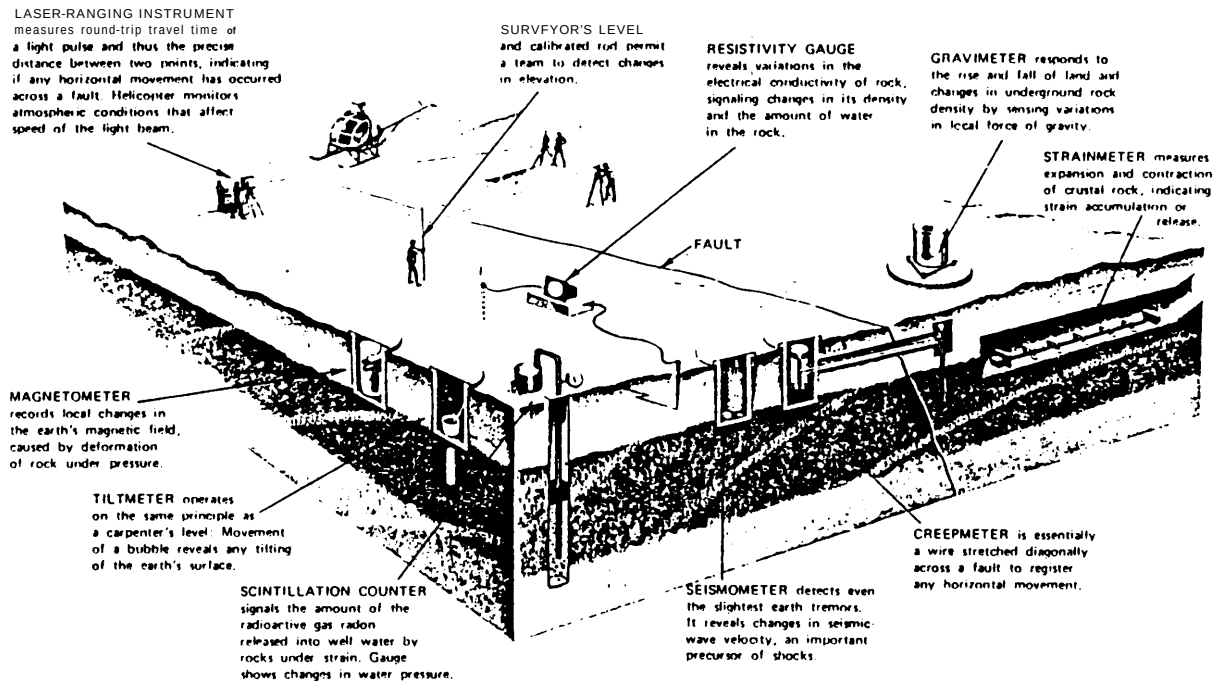
by denial of it. This process is called the '(normalcy bias," "illusion of invulnerability," or the " it-can't-happen-to-me" syndrome. Until a body of statistically valid and reliable research has been amassed, it may be better to be guided by accumulated data that point to apathy, procrastination, and disbelief as basic problems facing preparedness officials rather than adjustments motivated by fear. On the other hand, there may be differences between the reactions of those directly threatened, whose property lies in the target area, and those who reside in safer territory but whose financial investments are within the target area. These investors, not persona Iii' threatened by bodily harm, may not experience the threat-fear-denial syndrome and may withdraw their investments from the target area as a matter of fiscal prudence. Some ma v actually there invest there anticipation of realizing a net financial gain deriving from taxing, relief, insurance, or other practices.

The positive effects of prediction and of disaster itself have largely been overlooked. Power and others in a report on the Teton Dam disaster recovery, point out that once rebuilding begins the disaster areas mav experience an economic boom. ? The immediate injection of Federal disaster funds spurs the recoverv; there is a rush to get business and i ndustry back into shape. Here is where preplanning for postal isaster rehabilitation is vital if the rush to recoverv is to be channeled into improving the community. The prospect of newer, improved facilities a$_p$-pears to encourage investment. If preplanning is clone carefully and business is made aware that upgrading is possible, some capital flight that otherwise might occur after the disaster can be prevented.

Accurate prediction allows time for realistic preplanning by the business, financial, and industrial communities. It may also make it possible for community leaders, assisted 171 tile media, to mobilize commun itv spirit and, by so doing, create the "postdisaster euphoria" i n the predisaster period. [f the prepared-for disaster does n o r materialize, however, "postdisaster letdown" mav occur as well.

[John H. Powel, Jr., et al., *Adjustment Program for the Teton Disaster Area: Executive Summary*, Seattle, Wash., Boeing Computer Services, 1977.

Figure .6.—Concept of Earthquake Prediction Instrumentation



SOURCE. Painting by Davis Meltzer National Geographic Society. Reprinted with permission.

Still another positive effect is the opportunity for researchin$_g$ ways to circumvent the threat-fear-denial reaction so that effective preparation systems can be developed for future events. The resolution of tensions between positive and negative effects of prediction offers an opportunity that the implementation plan should not fail to address.

When earthquake prediction was first considered possible, debates arose over plans to evacuate large cities and over the problems that could result. Accordin$_g$ to structural engineers and emergency planners, the tide now seems to have turned more toward building reinforcement and the use of refuge areas. Most, if not all, cities in seismically active regions have areas that are highly vulnerable to earthquake damage, but they also have areas that are reasonably safe. Many buildings can be made more earthquake resistant bt practical means. The idea of mass evacuation is giving way to spot evacuation of the more hazardous sites. Long-term prediction, which will allow strengthening of buildings and dissemination of refuge information, and short-term warnings, which will allow temporary evacuation and school and business closures, should provide more safety with less disruption of the normal living patterns than mass evacuations.

Questions

1. Has too much emphasis been placed on prediction, to the detriment of the here-and-now management of the next damaging earthquake?
2. Does the plan rely so heavily on prediction that it will not be an effective tool for hazards reduction unless/until prediction technologies are perfected?
3. Does the plan recognize the differences between short-term programs, which need attention immediately, and long-term planning?
4. Does the plan tend to encourage actions that would make decisionmakers and the

public-at-large unrealistically dependent on prediction or warnings?

5. Does the plan give the impression that there is a large body of reliable data regarding either positive or negative effects of earthquake prediction?

6. Does the plan tend to emphasize the negative effects of prediction to the detriment of planning based on the positive effects?

7. Does the plan give the impression that it is based heavily on the expectation of certain negative effects?

8. Is the plan written in such a way that it may create self-fulfilling prophecies of negative impacts ?

9. Does the plan encourage community-based planning for implementing the positive effects of earthquake prediction and preparedness ?

10. Does the plan encourage community--based planning for in[-estimating and alleviating the true negative effects of earthquake prediction and preparedness?

11. Is there an equitable balance between research and planning funds apportioned for prediction/warning and those apportioned for immediate preparedness planning?

12. Does the plan provide for establishing: criteria for evaluating the current response capabilities of all Federal, State, and local entities concerned with earthquake preparedness and relief?

13. Does the plan encourage open scientific discussion with decisionmakers and the public-at--large about the progress of prediction research and its implications?

14. Does the plan provide for educating representatives of the news media regarding the facts and fallacies associated with prediction ?

15. Does the plan encourage planners and decisionmakers to rely on competent sociological studies regarding prediction and postdisaster behavior?

16. On what specific conclusions from social science research on disaster-related behavior-tor is the plan based? How specifically is this information utilized in the plan?

17. How does the plan balance emphasis on mass evacuation with refuge and reinforcement strategies?

18. Does the plan provide for allotment of funds to city and country governments for studies to determine refugee areas and spot evacuation areas?

19. Does the plan provide for readily available sources of funding for reinforcing public buildings and other structures for which reinforcement is feasible?

20. By what means are priorities set? What will be the need for, and how will one go about retracting, a prediction or forecast for a quake? Are the possible liabilities associated with prediction recognized?

21. There is a generally recognized uncertainty about forecasting earthquakes, but there is an equal, if not more important, uncertainty about the scale of risk. In a recent study, seven recognized experts evaluated the probability and year as well as the severity of a quake on a modified Mercalli scale, and horizontal ground motion, for 11 different regions of the country. It was clear that experts not only disagree but they disagree by factors of thousands to tens of thousands on important judgments. (See tables 5 and 6.) To what extent should this uncertainty be a key element in planning?

ISSUE 10
THE PICTURE OF THE PRESENT VS. THE IMAGES OF THE FUTURE: CHOOSING ALTERNATIVES

Present public policy actions are unlikely to have major short-term consequences for the quality of life or the public well-being. Their major effects, both planned and unplanned, will be in the future. It is useful, therefore, to look to the future and make explicit the assumptions about the future world.

Although human beings have the potential capacity for projecting themselves into the future and for making plans, they are essentially oriented to the here and now. For most people the idea of the "future" is either so remote that it

does not enter their consciousness, or it is largely based on the rules and conditions of the present.

Questions

1. What alternative futures have been examined and chosen for the variables entering into the plan ? By whom? On what rationale?
2. What are the explicit, extrapolative, and normative assumptions about the future with regard to earthquake hazards regions? What technology, public policy, population, and other variables have entered into those assumptions?
3. Does the plan provide a means for postdisaster planning to be completed in advance of the next disaster? How? By Whom? Under what guidelines and overall planning principles?
4. In the development of postdisaster recovery and rehabilitation programs, does the implementation plan encourage the use of safer sites, designs, a and techniques ?
5. Hour much hazards reduction is sought? How much is needed? How' much can be afforded ?
6. What implications do these choices have insofar as our other national priorities and resource commitments are concerned ?

ISSUE 11
THE PICTURE OF THE PRESENT VS. THE IMAGES OF THE FUTURE: RESOLVING AMBIGUITIES

The Act states that "It is the purpose . . . to reduce risks . . . from future earthquakes *in the United States . . .*"

Neither the faults that cause earthquakes nor the damages that result from seismic activity respect national boundaries. Thus, a quake with

Table 5.— Davis Besse (Ohio)

Expert respondent no.	1	2*	3	4	5	6	7	High/low differ by factor of
MM•• Intensity				Probability y per year				
V	10"'		10-'	7 x 10"'	lo"'"–		, 0 - 2	
VI	1 0-'		10-'	10-2	5 x 10-3		10"4	
VII	10-'		10"'	lo"'	1 0-3	1 o-'	lo"~	
VIII	lo"'			5 x 10-7	1 o-' 1		10-7	
Ix	10-5				10"6		10-"	
x	10"6						<10-8	
xl	10-'						< 10-'	
X11	10-a						<1 o-d	
Peak horizontal acceleration				Probability y per year				
.05g	1 o-'		10-5	8 X 10-3	5 x 10-'		10-2	
.1g	10-'	,0..	lo"'	2 x 10-'			10-4	
.15g	10-'			3 x 10-'	1 0-3	10-6	lo"'	,
.Zg	1 o"'	8 X 10-'		6 X 10-5			10-'	100000
.25g	1 o-'			6 X 10-'	1 0-'		, 0 - 6	
.3g	10-2			8 X 10-7			10-'	
.4g	10-'	5 x 10-'					lo"'	
.5g	10-5				1 0-6		10-'	
.6g	,0-6	3 x 10-'					< 10-3	
8g	10-7	2 x 10"5					<10-8	
1 .0g	10-a	1 x 10-'					<1 o-'	
== 1 .lg	10-'						<1 0"'	
				Dominant frequency and duration for 1O⁻²/year earthquake				
Cycles/sec	2	1-3	1-3	2-15		1/3-1 o		
Seconds	10	5	5	15		20		

'Probabilities per year are for accelerations greater than the Size indicated
" " Modified Mercalli Scale,

SOURCE D. Okrent, A Survey of Expert Opinion on Low Probability *Earthquakes.* University of California at Los Angeles UCLA.ENG.7515 February 1975.

Table 6. – Diablo Canyon (California)

Expert respondent no.	1	2"	3	4	5	6	7	High/low differ by factor of
MM•• Intensity				Probability y per year				
v			10-1	1 o-'	10-6		10-'	
VI				4 x 10-'			10-'	100,000
VII			1 0-'	2 x 10-2	5 x 10-3		, 0-2	
VIII			10"3	5 x 10-'	3 x 10-'		1 0"'	
Ix			10-5	10-4	10-4		,0-6	100
x			10 -'	10-5	2 x 10-6		10-7	
xI				2 x 10-'	10-6		<1 o"'	
X11							<10-7	
Peak horizontal acceleration				Probability y per year				
.05g		5 x lo"'	10-2	4 x 10-2			10-1	
.Ig		2 x 10-'	10-3	2 x 10-2	1 0 -'		1 0 -'	
.15g			1 0-3	7 x 10-'	5 x 1 o-'		1 0 -'	10
.20g		1 x 10-3	10-'	3 x 10-3	3 x lo"'		1 0 -'	
.25g			10-3	2 x 10-3	3 x 10-3		10-3	
.3g			, 0-4	10-'	10-3		,0-3	
.4g		6 x 10-4	10-4	3 x 10-4	2 x 10-'		10-5	
.5g			10-6	7 x 10-5	10-4		10-6	100
.6g		3 x 10-4		1 0 -'	2 x 10"'		1 0-'	
.8g		2 x 10-4		1 0-8	1 0-5		<1 0-'	500
1 .Og		10-'			2 x 10-'		<1 0	
>1.Ig					10-6		< 1 0 -	
				Dominant frequency and duration for 10-'/year earthquake				
Cycles/see		5	5-8	2-5				
Seconds			17	15				

• Probabilities per year are for accelerations greater than the size Indicated
. . Modified Mercalli Scale.

SOURCE D Okrent, *A Survey of Expert Opinion on LOW Probability Earthquakes,* University of California at Los Angeles UCLA-ENG.75 15 February 1975.

a U.S. epicenter may cause damage in Canada and Mexico, or a quake with an epicenter in Kamchatka may cause damage along the western coast of the United States. An earthquake originating beneath international waters may cause destructive tsunami along U.S. shores. The intent of the Act regarding these conditions is not clear. Does the United States assume legal and financial responsibility for reducing earthquake hazards in Canada, Mexico, and the U.S.S.R. h-em quakes *originating in* the United States? Is it the intent that the United States install monitoring equipment in Canada, Mexico, and the U.S.S.R. to protect against earthquakes that may cause damage *in the United States ?* Or is it possible that U.S. agencies could at some rime **refuse** responsibility for reducing tsunami haza ards because the causative fault is outside the 200-mile U.S. **territorial zone?**

There are fault systems that traverse the Canadian and Mexican borders. Does the Act raise the spectre of future legal hairsplitting over whose fault is at fault, or worse, international incidents over responsibility for prediction, control, and disaster relief? At some Future time may te Unitcd States be accused of permitting damage to (for instance) Russian installations by failing to control fault tension in the Aleutian-Alaskan area—or conversely, of causing damage when seismic control experiments misfire and result in larger earthquakes than intended? May one side of a transborder faults system be experimented upon without prior arrangements with the other country involved ?

These questions and others of international liability arise from the ambiguous wording in the Act itself and from its failure to address the nature of the geophysical phenomena.

Does the plan identify these and other ambiguities in the Act? How were these handled in the implementation plan? Is there a need to return to Congress for clarification of any ambiguities or uncertainties of intentions?

ISSUE 12
THE "NORMAL" DISASTER VS. THE CATASTROPHE

There is incongruity between acknowledging that a maximum credible disaster—a disaster taking thousands of lives and running into tens of billions of dollars—implies major discontinuity, and the desire within Government to maintain a comfortable sense of continuity of institutions. It would be worthwhile to identify a threshold of disaster at which point the normal operating laws, rules, and regulations of society would need to be suspended during some extended recovery period. This concept would go well beyond martial law and suggests that debts, insurance, bank payments, commercial obligations, and so on might be handled in a unique way. Postwar Europe's recovery provides a possible model. Such a strategy might address many of the difficulties associated with major disaster (or its prediction) that could disrupt the whole U.S. or a regional economy.

This conflict between the necessity for saving lives and restoring the economic balance of the country (or a region) by such drastic measures on the one hand, and the constitutional questions raised by such solutions on the other, requires careful analysis and anticipatory planning.

Questions

1. Does the plan face the reality of identifying a level of disaster so severe that the normal operating laws, rules, and regulations of society would need to be temporarily suspended or drastically modified during a long recovery period?
2. Within the framework of a major/maximum credible disaster, could one anticipate that fire might be particularly dominant? To what extent is dealing with fire integrated into the plan and to what extent is special foreign experience or historical American experience being utilized?
3. In a major holocaust will there be special need for rubble removal equipment? Where are these needs being considered ?

ISSUE 13
INTERAGENCY CONFLICTS: NEW VS. EXISTING AGENCIES

Public Law 95-124 provides for leadership to coordinate the efforts of the many agencies. Most States already have agencies responsible for emergency preparedness, environmental concerns, and geological matters, and these have ties with Federal agencies with implementation responsibilities.

Shall each agency take responsibility for managing its own programs and coordinating with other agencies, or shall they assume responsibility for creating one body with representatives from each agency? This question can be raised at all levels of government. On the one hand, agencies generally resent outside direction. Yet, few agencies can boast a good track record of cooperation with other groups in the absence of a central coordinating entity. Interagency committees are often unwidely creatures, however, and as a rule are not as efficient or effective as a single agency.

It is inevitable that there will be interstate conflicts where laws and procedural regular ions are concerned. The resolution of this conflict is closely tied to the basic approach of the plan; is it to be from above or broadly based on the expressed needs of the affected parties?

Interaction among the several State agencies and among State, local, and regional bodies ranges from cooperation to competition so intense that it impedes effective action. It may be that the only solution in some States will be to consolidate all earthquake planning functions into one new agency. In others, varying degrees of consolidation and coordination will be required. In still other States, effective interagency programs may already be functioning.

Existing agencies at both Federal and State levels have the advantage of experience and personnel familiar with problems and procedures. On the other hand, bureaucracies tend to become overcommitted to their own sets of regulations and priorities. The implementation plan must balance these conditions in order for the legislation to be effective.

Questions

1. Does the plan make use of existing agencies, programs, and systems or does it call for the establishment of new ones?
2. How is the plan related to the President's Reorganization Plan for disaster preparedness and response?
3. How will the coordination affect more than information exchange and achieve real integrated action ?
4. Does the plan provide for resolution of interagency conflicts over procedures to coordinate work efforts?
5. Is the plan sufficiently flexible so that these conflicts can be resolved in the manner best suited to each level of government or to each local area?
6. Does the plan provide constraints necessary to achieve an appropriate balance of power among agencies?
7. Does the plan provide for effective criteria for deciding when new agencies or coordinating bodies are necessary to surmount interagency or interlevel conflicts? Are there effective mechanisms for their creation ?
8. Does the plan call for resolution of statutory conflicts among States by imposition of new Federal laws or regulations?
9. Does the plan encourage voluntary resolution of legal conflicts by the States themselves?
10. Does the plan allow for model State laws or guidelines that States may use to resolve interstate conflicts in disaster planning and rehabilitation ?
11. What new legal or equity issues will arise under the plan ? How is this determined? How will they be resolved?
12. Seismology is a concern of the Department of Defense, particularly through its network for nuclear test detection. To what extent will such test information be made available under the new plan?

ISSUE 14
URGENCY OF NEED VS. LIMITED CAPABILITIES

It is often widely believed that brief, all-out efforts can solve major problems or accomplish great feats. Unfortnuately this is rarely justified by events.

The question of how much effort is enough must be resolved. The tendency to meet the most immediate needs and to go no further than an agencies feels required to go leads to focus on a short-term partial solutions ("satisficinig"). This undercuts more effective, long-term measures.

If the implementation plan is to succeed, it must balance aims and intent on the one hand, and specific plans to put those aims to work on the other.

The final philosophical conflict for examination is the tension between the strict interpretation of the Act and the freedom to interpret its intent and purpose even when the latter facets are not spelled out in the original legislation.

Congress and the President will need to be apprised from time to time, certainly at the end of the initial appropriation period, if not sooner, of the success or failure of the plan.

If the plan is succeeding, then some measure of its success must be made visible and available. If the plan is not working, it must be recast or abandoned.

Questions

1. With or without a major earthquake, can hazards reduction be evaluated?
2. What does "hazards reduction" mean when interpreted as explicit agency objectives?
3. Does the plan provide a mechanism for continuing assessment of its effectiveness?
4. What are the measures of the plan's effectiveness?
5. How will nonquantitative measures of success be used in evaluation?
6. What is a reasonable schedule of accomplishments?

7. How does the plan encourage finding *the* best solutions possible, consistent with the state-of-the-art, and reasonable, fiscal constraints ?

8. Does the plan discourage intensive effort, restricting time and money to temporary or "band aid" approaches to earthquake problems?

9. Does the plan encourage speed at the expense of thoroughness?

10. Does the plan favor a rigid, narrow, conservative interpretation of the letter of the Act and its own specifications? Does the plan allow for a generous or common sense interpretation of the Act and flexibility in its own requirements?

11. Has the plan examined the ability and willingness of the agencies charged with carrying out the plan? How are the nonresearch aspects of the plan to be funded? Are there political conflicts of interest that will impair the plan's functioning? Do the advocates of the plan have constituencies both within government and without who are powerful enough to successfully support the execution of the plan's objectives and programs?

12. Does the **plan** tend to *self-destruct* after the initial appropriation period, or does it contain provisions for the gradual phasing in and out of specially funded programs or projects?

13. Does the plan contain mechanisms for the establishment of ongoing programs?

14. Does the plan anticipate and provide for the gradual turnover of any successful Federal projects to the appropriate State or local agency or jurisdiction?

THE NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM

June 22, 1978

Executive Office of the President

Washington, D. C. 20500

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THE NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM

INTRODUCTION

The purpose of the National Earthquake Hazards Reduction Program — in accordance with the Earthquake Hazards Reduction Act of 1977 — is to reduce the risks of life and property from future earthquakes in the United States.

The Act (Public Law *95-124)* directs the President "to establish and maintain an effective earthquake hazards reduction program." To implement such a program, the President is is to develop a plan, which shall "set year-by-year targets through at least 1980, and shall specify the roles for Federal agencies and recommended appropriate roles for State and local units of government, individuals, and private organizations."

Earthquakes pose perhaps the greatest single-event natural hazard faced by the Nation. An earthquake can affect hundreds of thousands of square miles, can cause damage to property measured in the tens of billions of dollars, can cause loss of life and injury to tens of thousands of persons, and can disrupt the social and economic functioning of the affected area. During this century, earthquakes, because of their infrequency, have caused less damage in the United States than have hurricanes, tornadoes, or floods. Major earthquakes in other parts of the world, however, have shown the destruction and disruption they can cause, and the potential for disaster has multiplied here in recent years with the rapid development of the most seismically prone portions of the country.

While earthquakes in the United States occur most frequently in States west of the Rocky Mountains, 39 states are known to have the potential to experience moderateand severe earthquakes. During the history of this country, devasting earthquakes have occurred in the West, Midwest, and East, and are expected to occur again. Recent developments in earth science have lessened the mysterious nature of earthquakes, and offer promise in understanding their nature and effects. Scientific earthquake prediction is a real possibility, and in fact has already saved lives in other parts of the world. At the same time, much progress has been made in understanding the response of buildings and other structures to shaking from earthquakes, enabling us to build more resistant structures. Much remains to be learned in both the earth science and engineering aspects of earthquake problems. But, armed with the existing and merging knowledge about earthquakes, their effects and how to reduce their consequences, we can develop a strategy for a National Earthquake Hazards Reduction Program. AS more is learned the strategy can be modified, but we can begin now.

Each year the United States spends hundreds of millions of dollars on relief to victims of natural disasters and on the reconstruction of damaged communities. Much, but certainly not all, of this post-disaster expense could be saved if mitigating actions were taken before the events

occur. The Nation must strive to find the proper balance – a balance that is both compassionate and cost effective – between efforts to mitigate the impacts of disaster and efforts to provide relief to victims. The National Earthquake Hazards Reduction Program addresses measures to mitigate this one particular kind of natural disaster – an earthquake – that can cause widespread economic disruption and personal tragedy.

Although we can make some plans for future uncertainties, most people tend to avoid thinking about the possibility that a disaster may personally befall then. This tendency is reinforced by the fact that most individuals have not recently experienced a disaster and so appropriately think that the odds qainst the occurrence of a disaster at any given time are overwhelmingly in their favor. Differences in perception of risks also blunt recognition of the need to undertake hazards reduction and disaster preparedness measures. Hazards reduction actions based primarily on the initiative of individuals or small groups have generally failed &cause they failed to recognize the human tendency to deny existence of danger and to assure that everything is all right until events clearly prove otherwise. Also, plans and other actions must often be undertaken on a large and coordinated scale, beyond the capacity of individuals or small groups. Leadership is required to encourage the appropriate consideration of seismic risk in making decisions that affect the ability of a community – and indeed the Nation – to resist the impact of earthquakes.

To accomplish the overall goal of reducing the risks to life and property from future earthquakes, the National Earthquake Hazards Reduction Program will emphasize:

- o Leadership – Actions to reduce earthquake hazards involve numerous Federal agencies, State and local governments, a variety of institutions in the private sector, and the public. Consequently, a mechanism for leadership and coordination is essential.

- 0 Partnership – Actions taken by the Federal government alone will have little effect. State and local governments and the private sector have principal responsibilities for action. For success, the planning, execution, and review of the Program must involve non-Federal participation, including State and local government, business, industry, the design professions, the research community, and the public.

- 0 Implementation – A National Program responsive to the legislation of the Congress must contain actions aimed at the following objectives:

  - Develop measures to prepare for earthquakes, to evaluate earthquake predictions, to warn residents of an impending earthquake if possible, and to ensure that a comprehensive response will be made after the occurrence of an earthquake;

— Develop ways for governmental units, industry, and the publlc to use existing and developing knowledge about regional and local variations of seismic risk in making their land use decisions;

— Develop and promulgate specifications? building standards design criteria, and construction practices that will provide appropriate earthquake resistance for new and existing structures at reasonable cost;

— Consider the reduction of earthquake hazards through alternative provisions and requirements for Federal and Federally-financed construction, loans, loan guarantees, grants, and licenses;

— Determine the appropriate roles for insurance? loan programs, and public and private relief efforts in moderating the impact of earthquakes;

- Provide researchers, the design professions, the construction industry, and the public with data and information to achieve the purpose of the Program.

o Research - Improved techniques for hazards reduction over the low run require research into the basic causes of earthquakes, the means to try to predict and perhaps control them, the develop ment and regional application of methods to evaluate and delineate their potential effects and seismic risk, the development of methods for increasing seismic resistance in manmade works, the exploration of impacts on the community of earthquakes and the consequences of alternative mitigation policies, and the utilization of foreign experience.

GUIDING PRINCIPLES FOR A NATIONAL PROGRAM

The National Earthquake Hazards Reduction Program is comprehensive in scope, establishing a balanced program of hazards reduction measures. The program breaks new ground in attempting to achieve, with a realistic expenditure of resources, an effective state of preparedness for, and protection from, a disaster characterized by a low probability of occurrence but with a high potential for destruction, damage, and disruption. The task is made even more difficult by the large number of groups in both the private and public sectors – often with conflicting objectives and interests – that need to be mobilized in support of the effort.

Decisions affecting earthquake safety must be made at virtually every level of society – individual, family, community, and national. Most of these decisions are made in the private sector, often subject to some

governmental constraints and incentives. The achievement of a safe seismic environment is therefore basically a responsibility shared by all levels of the public and private sectors. This National Program can be successful only if both governmental and private leaders recognize the need for active participation in planning and management at all levels. They must all take responsibility for stimulating and supporting hazards mitigation actions by the private sector.

The numerous groups that will be involved in implementing this Program include not only Federal, State, and local government officials, but also representatives from industry, business, volunteer associations, professional groups, research and academic institutions, and the public. Within the context of the diverse roles played by these groups, the program identifies those actions that the Federal, State, and local governments and private individuals can appropriately undertake. The Federal government can play a significant, but not dominant, role. The Federal government must set an example for others to emulate by its own actions, including the institution of more effective hazards mitigation measures in its own facilities. Existing Federal government resources for providing technical assistance and the acquisition and dissemination of data and information will be amplified and used to assist State and local governments and the private sector. Appropriate State and local governmental actions, and those that groups in the private sector may undertake, are also indicated within the framework of a coherent national effort.

This Program has been formulated with, and its implementation will be governed by, the following guiding principles:

- The priorities of hazards reduction are to & based on relative risk; that is, the probability of significant loss of life and property, considering the population exposed, the nature and magnitude of the hazards posed by manmade structures to the population, and the likelihood and character of significant earthquakes. Regional differences in the nature and magnitude of the risk and of the perception of the risk require a flexible approach.

- While the Federal government can take a strong, exemplary position with reqard to its own facilities and develop guidelines and standards for Federally-assisted or licensed critical facilities, the effort to improve local land use and building codes --as a basis for all private construction, including Federally-assisted, noncritical construction — must be accomplished by persuasion and encouragement, particularly through working with professional organizations and State and local officials.

- Earthquake hazards reduction must not only take into account the direct natural hazards from faulting and vibration, but also the indirect natural hazards from tsunamis, seiches, landslides, floods, soil consolidation, soil failure, and slumping. Damage to works of man by these natural hazards leads to both primary hazards such as

?

structural failure, and secondary hazards such as fire? flood, and the escape of contained toxic or hazardous fuels and materials "

- Experience both in the United States and abroad has proved that buildings and other structures can be designed so as to protect Life safety during very strong ground shaking from major earthquakes. For some buildings and structures the additional cost of earthquake resistance is quite small; in other cases the costs would be very significant.

- Prediction cannot, in the near future, be relied upon as an effective tool to reduce earthquake casualties (for example, to avoid the problem posed by existing hazardous buildings). However, since scientific breakthroughs could come at any time, we must prepare to cope with different levels Of Predictive capability.

- Hazards reduction procedures, whenever and wherever possible, need to be incorporated into existing organizations? institutions legislation, regulations, rules, building males, relief procedures, and loan requirements, so that they are part of established activities rather than being superimposed as separate and additional. As the local building codes improve through time as a result of persuasion and encouragement, it may be appropriate to increase gradually the seismic provisions in requirements for Federal assistance.

- Outside assistance to the local community must be planned for quick identification of needs that cannot be handled locally, and for provision of aid to supplement, rather than replace local efforts. Our society has a great resilience and recuperative power when calld upon to respond to sudden disaster.

- Special attention must be given to persons who are particularly vulnerable to earthquake hazards (the poor, the aged, the handicapped, the children) to provide them equal protection and ensure that they do not suffer disporportionately.

- TO be acceptable in regions characterize@ by lower, but significant, seismic risk, earthquake hazards mitigation activities should lead to the reduction of risks from hazards other than earthquakes and be coordinated with efforts to protect people and property from other potential hazards and disasters.

- o International cooperation on earthquake hazards research should be fostered as essential to ensure opportunities for mutual learning. Studies of foreign experience and exchange of information are therefore a fundamental part of this Program.

- o Continuing evaluation is needed to assess the strengths and weaknesses and the successes and failures of the Program. An annual report to Congress will reflect the progress and evaluate the effectiveness of the Program.

PRIORITIES FOR IMMEDIATE ACTION

Some actions for earthquake hazards reduction can begin immediately while others must await research results or the committment of financial resources. Of the tasks outlined in this plan, the highest priorities for immediate action are:

- • The establishment of a focus– a lead agency – to provide national leadership and to guide and inordinate Federal activities;

- o The determination of the interest of States for the development of State and local strategies and capabilities for earthquake hazards reduction.

- o The completion of Federal, State, and local contingency plans for responding to earthquake disasters in the densely populated areas of highest seismic risk.

- o The development of seismic resistant design and instruction standards for application in Federal construction and encouragement for the adoption of improved seismic provisions in State and local building males.

- 0 The estimation of the hazard posed to life by possible damage to existing Federal facilities from future earthquakes.

- 0 The maintenance of a comprehensive program of research and development for earthquake prediction and hazards mitigation.

The tasks required to initiate these actions to achieve the long-term objectives of the National Earthquake Hazards Reduction Plan follow.

MOVING TOWARD A NATIONAL PROGRAM

Providing National Leadership

A central focus is needed to stimulate and inordinate earthquake hazards reduction activities within the Federal government and throughout the Nation. Pending the recomme,ndations of the president's Reorganization Project and within the 300 days from enactment of Public **Law** *95-124,* **a lead** agency will be rimed to assume this role, providing leadership in coordinating earthquake hazards reduction activities in the appropriate Federal agencies and in assisting State and local govermenments in planning and implementing their own programs. In carrying out these responibilities, the lead agency will consider regional differences in the nature and perception of the earthquake threat and encourage flexible programs embodying earthquake hazards reduction in efforts to mitigate other natural hazards where feasible and appropriate. The lead agency will have primary responsibility for maintaining an overview of the National Program and identifying opportunities and needs.

The lead agency will be responsible for the development of guidelines to assist Federal agencies involved in construction in implementing earthquake hazards reduction elements in their ongoing programs. To develop these guidelines for consideration, by October 1978, the lead agency will organize and lead an Interagency Committee on Seismic Safety in Construction. This committee will be composed of representatives of all Federal agencies significantly engaged in construction, the financing of construction, or related activities. Following the appropriate review, the guidelines will be implanted by Executive Order as required.

By July 1979, the lead agency will complete a detailed work plan for its continuing role, including procedures for monitoring the assignments of responsibility contained in this Program and for participation in programmatic review and assistance in budgetary review. In addition, the work plan will describe the mechanisms that will be used to identify additional areas for hazards reduction activity through consultation with other Federal agencies, State and local governments, and private relief groups, including the establishment of any advisory groups or interagency committees that may be required. The work plan will address procedures for developing earthquake hazards guidelines for Federal agencies to include in their ongoing programs, and the development of guidelines for reconstructirq damaged communities to make them more resistant to future earthquakes. Each year the lead agency will summarize progress toward the goals of tie Program in a report submitted to the President for transmittal to *Congress.*

Improving Contingency Planning and Emergency Response

Following a destructive earthquake, all levels of government and the private sector should join to the extent necessary in providing assistance to the victims. This assistance will be most timely and effective if based on a set of coordinated Federal, State, local, and private contingency plans.

General disaster planning would probably not be adequate to cope with the unique aspects of a destructive earthquake in or near a heavily populated region.

The Federal Disaster Assistance Administration will develop a schedule, covering the areas of high seismic risk throughout the country, for the completion of Federal contingency plans and for assistance to State and local governments in completing their response plans. This schedule will reflect 1) an evaluation of the contingency planning completed to date, 2) priorities accorded to the level of seismic hazards and interest of the affected communities, and 3) the recognition that contingency plans must be preceded by estimates of potential damage and casualties. These plans should consider the developing capability for predicting earthquakes and their effects. If a reliable capability develops, opportunities should be identified to utilize governmental and private resources for post-disaster action before the occurrence of an earthquake. This schedule will be completed in time to be considered for the budget for Fiscal Year 1980.

The Federal Disaster Assistance Administration will bear a continuing responsibility for overseeing the revision of Federal earthquake contingency plans and for stimulating the revision of State and local contingency plans as new information on earthquake hazards is developed and as the perception of this threat in affected communities increases. Guided by these plans, State and local governments can assess the potential impact of earthquakes on safety to life and on essential community facilities and can take steps to reduce the loss of life and to ensure the maintenance of vital services.

Evaluating Earthquake Predictions

The development of a reliable capability to predict earthquakes is a fundamental research objective. As we move toward the goal of making scientifically credible earthquake predictions, information may develop that – although insufficient at the time for issuing an earthquake prediction – may heighten scientific concern about the imminence of a destructive earthquake. This information mustbe evaluated and communicated to responsible public officials in much the same way that scientifically credible earthquake predictions will be evaluated and communicated.

The responsibility for evaluating and communicating earthquake predictions and other information of this type will rest with the Director of the U.S. Geological Survey. To resolve questions of liability, additional legislation may be propsed. The Director will be assisted in this task by the National Earthquake Prediction Evaluation Council, a Council to be composed of scientists from inside and outside government.

This Council will be established in 1978. The responsibility for warning the people about the imminent danger from a natural hazard and to advise or direct them on how to respond is principally a function of State and local government. As a basis for determinig their own actions in response to earthquake predictions, State governments in highly seismic regions may decide to establish their own advisory mechanisms. Scientific societies such as the Seismological Society of America, the Geological Society of America, and the American Geophysical Union are urged to develop ethical and scientific guidelines to be followed by individual scientists and scientific institutions in issuing earthquake prediction.

The current tsunami warning system of the National Oceanic and Atmospheric Administration will be continued. Advancesmade in earthquake prediction will be incorporated into this system to improve its overall effectiveness and efficiency.

Much remains to be learned but the social and economic effects of an earthquake prediction and abut how officials can respond so as to minimize both potential losses and possible negative impacts. The National Science Foundation will continue its program of research to provide background information for these policy decisions.

Preparing National Seismic Risk Assessments

An assessment of the relative frequency and characteristics of earthquakes in the United States is needed. National maps are needed showing the degree of seismic risk and providing information necessary for engineering design of structures. - These maps are needed to establish national priorities for earthquake hazards reduction activities, for model building codes, and as a basis for incorporating earthquake hazards reduction provisions – where appropriate – in a wide variety of Federal programs, including those that observe requirements of locally adopted model codes. These maps are not intended for local zoning or the evaluation of specific sites but for showing the broad variation of seismic risk throughout the Nation. Under the recently agumented program of the U.S. Geological Survey, high priority will be given to the production of such seismic risk maps. However, fundamental scientific problems must be solved before fully satisfactory maps can be instructed, and it is not realistic to expect that one "final" map or series of maps can be produced in the near future. Instead, while researchers address the fundamental problems, a series of maps will be produced to meet immediate and growing needs. These will be revisal as new information becomes available.

By July 1979, the Geological Survey will complete a review – in consultation with the Interagency Committee on Seismic Safety in Construction, professional organizations and model code groups – of the priorities and types of information to be shown on national seismic risk maps. A new draft national seismic risk map (or maps) will be available for review by interested agencies and groups by July 1980, and a completed map (or maps) will be published by July 1981. Maps will then be revised and updated as required.

In addition to the need for national-scale assessment, information is needed on a regional scale but the nature and distribution of earthquake hazards for use in making State and local decisions about construction and the use of land. The program of the Geological Survey emphasizes the development of new techniques for identifying and evaluating earthquake hazards, such as active faults and the ground renditions that affect the distribution of damage. The program also emphasizes the application of existing and developing techniques to the evaluation and regional delineation of earthquake hazards, particularly in the regions of highest risk. By January 1979, the Geological Survey will complete a priority schedule for the regional evaluation and delineation of earthquake hazards for the next five years, taking into account the views of State and local governments, hazards evaluation programs of the Nuclear Regulatory Commission and other agencies, differences in the nature of the hazards in each region, and the current state of knowledge in each. As these studies proceed, particular attention will be given to the timely publication of hazards information in a form readily understood by nonspecialists.

Although this regional information will provide a significant and necessary framework, it will rarely be sufficiently detailed to be used in making decisions about local construction, local land use planning, or the evaluation of specific sites. State and local governments may find it desirable to build on the Federal program in developing detailed information on which to base their decisions affecting instruction and land use. Planning new construction to avoid especially hazardous zones, where possible, is an extremely effective mitigation measure. Agencies and firms planning special or critical facilities appropriately bear the incremental cost of information required for their detailed analysis of specific sites to comply with the guidelines and requirements of States, local communities, or the Federal government.

Making Decisions for Federal Lands

Wise decisions about the use of land are – in the longrun-among the most effective means to mitigate the hazards of earthquakes. Most of the decisions are made by local governments and in the private sector. The Federal government must set an example by carefully considering earthquake hazards in managing the lands it owns. The planning for these largely undeveloped lands, with a few exceptions, represents the sum of many decisions made by various departments and agencies. Most of the lands are in the western half of the Nation where the hazards from earthquakes are generally greater than elsewhere. Currently, in some areas, more consideration is given to earthquake hazards in making decisions for private lands than for adjacent Federal lands. Henceforth, in developing these Federal lands, decisions about the siting and construction of facilities affecting the safety and welfare of the public or providing vital services must reflect consideration of seismic hazards. Therefore, the lead agency will work with the principal land-management agencies in the Departments of Interior, Agriculture, Defense, and Energy, and others to develop guidelines, by 1980, indicating when and how earthquake hazards should be taken into account.

Improving Codes and Construction Standards and Practices

Criteria for the earthquake-resistant design of new construction used in many current Federal, State, and local building codes, standards and practices, do not reflect the current state of the art and should be updated. These codes and standards and the professional practices underlying them should not only represent our best knowledge, but be adaptable to different areas of the United States according to differing seismic risks and the costs and benefits they entail. The agencies involved in construction, working through the Interagency Committee on Seismic Safety in Construction, will develop seismic design standards for Federal building construction. The target date for completion of these standards and the initiation of their testing by Federal construction agencies is 1980. Implementation of the standards will be considered following testing and analysis of costs, and will utilize an Executive Order if required. These standards should reflect regional differences in the earthquake hazards placing emphasis on providing life safety, and should build upon existing model cedes where feasible.

The vast majority of the construction in this country is undertaken by the private sector and regulated by local government. To assist State and local governments, industry, and the public in developing construction standards, criteria, and practices, the National Bureau of Standards will work with the Department of Housing and Urban Development, other Federal agencies (particularly those performing research), the National Institute of Building Sciences, professional organizations, model code groups, and State and local building departments. The Bureau will assist and cooperate with these groups in continuing the development, evaluation, and improvement of model seismic design provisions suitable for incorporation into local codes and practices. Incorporation of these seismic design provisions into local codes is, of course, voluntary, but the provisions must be flexible and give consideration to rests and benefit% regional variation of seismic hazard, and adaptation to local conditions. They must also be adequately tested. This will be a continuing responsibility of the Bureau.

Reducing Hazards From Existing Buildings and Other Facilities

Most deaths and injuries in earthquakes have been caused by collapsing buildings — generally older buildings and often those made of unreinforced masonry, although some modern buildings are also vulnerable. The public's vulnerability to earthquakes over the coming years will be dominated by these existing hazardous structures. Most of these buildings are privately owned, but many are owned by Federal, State, and local governments. Almost all are expensive to upgrade, and thus present a very difficult problem of public policy for all levels of government. Over the lonq term, the potential to predict, reliably, damaging earthquakes may present an economically attractive alternative to upgrading substandard structures. However, the reliable prediction of earthquakes is likely to be many years away. In the mean time, it is important that hazards be reduced from those structures presenting the greatest risk in terms of occupancy and potential secondary impacts.

Special attention must be given to those structures that provide vital community services or pose unacceptable risks because of high occupancy. Some buildings, poorly designed or constructed from the point of view of seismic resistance, may not warrant reinforcement or replacement either because the collapse of the structure would not cause loss of life, injury, significant damage to contents, or loss of critical function, or because the structure is of great historical interest, has a low occupancy, would be impractical to reinforce or replace and for which the community is prepared to accept the risk. In some cases it may be most cost effective to achieve an increment of improved seismic resistance, but not require upgrading to meet the criteria for new construction.

Because of the astronomical costs of retrofitting whole classes of hazardous buildings, it is essential to reach a realistic and cost effective solution to this problem. The Federal government must set an example. agencies of the Federal government own or lease hundreds of thousands of buildings and other structures – examples include warehouses and hospitals, office buildings and defense installations. The cost of even a detailed field assessment of the seismic resistance of these structures would be very high. Theerefore, the lead agency will develop – working closely with, and drawing on the expertise of the General Services Ministration, the Department of Defense, Veterans Administration, the Department of Housing and Urban Development, and other Federal agencies owning buildings and other structures – a targeted strategy to identify the Federally-owned structures that present unacceptable risks – considering their use, occupancy, vulnerability to earthquakes, and the magnitude of the earthquake hazard. Several methodologies to approach this problem are under development by Federal agencies and by the State of California Seismic Safety Commission. The strategy should be outlined by the first half of 1979 to allow the General Services Administration and the Department of Defense to test and improve the strategy in Fiscal Year 1981. When the strategy is developed adequately for widespread application at reasonable cost, the agencies can request additional funds for implemmentation.

AS structures that present unacceptable risks are identified, each agency will include corrections of seismic deficiencies along with other necessary improvements to maintain a balanced annual construction program within its available resources and consistent with its other systemwide priorities. Possible corrections may include retrofitting, replacement, modification of use or occupancy, or simply removal from service. Corrective measures must consider other factors than earthquake safety alone and must be undertaken in a reasoned way. The strategy for identifying hazardous buildings will be coordinated with the Federal Energy Management Program of the Department of Energy where feasible and appropriate.

Two programs provide examples of what can be done. Since the 1971 San Fernando earthquake the Veterans Administration has achieved significant progress in reducing the seismic vulnerability of hospitals. The Department of Defense has begun the upgrading of existing barracks-type buildings in high seismic areas to improve life safety as part of

their modernization and is accomplishing seismic strengthening of existing hospitals in high seismic areas in conjunction with upgrading their mechanical, electrical, and safety systems.

In addition to identifying Federally-owned structures that present unacceptable risks, the General Services Administration will prepare guidelines, by January 1980, for evaluating seismic hazard in leasing of buildings. By applying standards for seismic resistance to prospective leased buildings, the Federal government will encourage the gradual reduction of hazard from existing privately-owned hazardous structures.

State and local governments wishing to explore approaches to the problem posed by existing hazardous buildings within their jurisdictions may obtain Federal assistance through existing planning grant programs. Some Federal assistance for actually implementing a reduction in the hazards posed by existing buildings is already available through a variety of existing Federal programs such as the Community Development Block Grant Program of the Department of Housing and Urban Development.

Ensuring the Safety of Critical Facilities

Facilities such as dams and hydraulic structures, nuclear reactors, liquid natural gas plants, and storage facilities for explosive and hazardous materials, have the potential for significantly increasimg the destructive impact of an earthquake, should they fail, particularly near a populated region. Lifelines, such as transportation routes and facilities, energy transmission facilities, water supply systems, sewage disposal systems, and communication systems, are all critical to the vitality and resilience of a community. Therefore, special attention must be given to the earthquake resistance of these critical facilities. Most of them are owned by the private sector or State or local governments. The Federal government also owns many critical facilities, including dams and storage facilities for hazardous materials; it also supplies funds for construction for such facilities as transportation and sewage systems; and it licenses some private facilities including nuclear power plants. Currently, earthquake hazards normally receive substantial attention when siting and constructing these critical facilities.

Owing to the limits of our present understanding of earthquakes and their effects, however, geologists, seismologists, and engineers commonly must attach large uncertainties to their quantitative estimates of earthquake hazards. Reservoirs and fluid injection wells pose special problems because, in some instances not yet fully understood, they seem to induce earthquakes. Although it is usually possible to design and construct facilities with an appropriate degree of safety for the use intended, the quantitative uncertainties sometimes virtually immobilize the process of decision making. Delay is often excessive as arguments are made about the appropriate level of conservatism in design and construction. New information developed through research and through the regional evaluation and delineation of earthquake hazards will help to reduce these uncertainties. In other cases the delay is caused as successive organizations conduct

their safety and technical reviews. The economic cost of such a delay can equal the cost of a very substantial increment of the conservatism in design. At the same time, requirements for public safety and the satisfaction of potentially affected communities give rise to the need for independent review and public participation in the planning process.

Several activities are already underway within the Federal government to address significant problems relating to critical facilities that are of particular relevance here. The Administration is proposing legislation to revise the procedures for licensing nuclear power plants. This legislation aims both to increase the participation of State governments in the decision process and to reduce the time required to get new power plants on line. It encourages early identification of geological conditions at prospective power plant sites and the banking of sites for future use. Earthquake-related issues are among the most difficult faced by the Nuclear Regulatory Commission in the licensing process and the Commission supports a research program aimed at their generic solution. In addition, the President recently established, under the leadership of the Secretary of energy, an Interagency Nuclear Waste Management Task Force to formulate recommendations for establishment of an Administration policy with respect to long-term management of nuclear wastes and supporting programs to implement this policy. Among other considerations, attention will be given to the geologic and seismologic aspects of this problem.

In November 1977, the Federal agencies responsible for dam construction completed a report maintaining draft guidelines for the safety of Federal dams. These guidelines contain provisions regarding earthquake resistance and independent review. Upon completion of a review of these guidelines now being conducted by the Office of Science and Technology Policy, they will be implemented by all Federal agencies. Further, both the Corps of Engineers and the Bureau of Reclamation and other agencies involved in dam construction have established requirements to include seismic design considerations – in accordance with the latest state of the art – for new dams and appurtenant structures. There are requirements providing for revaluation of existing dams to determine their earthquake resistance in accordance with the latest standards. In addition, the Corps of Engineers has begun the inspection of approximately 9,000 nonfederal dams that could be the cause of substantial loss of life and property in the event failure. Among other considerations, the Corps will make an assessment of the potential vulnerability of these dams to seismic events and will recommend additional seismic investigation of these dams where required. Results will be made available to States to encourage them to initiate effective non-Federal dam safety programs.

Special attention must be given to facilities that will be vitally needed following a destructive earthquake. Hospitals, fire and police stations, communication and administration centers, water and fuel storage facilities, and transportation facilities and other lifelines, will be needed as much or more after an earthquake than before. The Federal

agencies involved, working through the Interagency Committee on Seismic Safety in Construction, will develop special guidelines for ensuring the serviceability of these facilities after a destructive earthquake. These guidelines will then be considered for new facilities of this type constructed or financed by the Federal government.

To illustrate this point, the grant and Federal-aid programs of the Department of Transportation rely upon existing national or local cedes for design requirements to provide resistance to seismic forces. The fact that these codes do not provide adequate consideration for some of the special types of structures used in transportation structures has been recognized. The Federal Highway administration, for example, has been working actively with the State of California and the American Association of State Highway and Transportation Officials to develop improved seismic requirements for bridges and tunnels, and has sponsored research on these rotters to provide an adequate technological base. This work has been coordinated with the National Science Foundation and other Federal agencies engaged in such research.

Reducing Risks Through Public Information and Participation

Exchange of information is the single most important element and will be the catalyst, in motivating the vast array of individuals who must take actions – mostly voluntary – to effect reduction of earthquake hazards. Information must flow in many directions among the public, professionals, research workers, and public officials. Leaders of business and industry must be aware of risks; research workers must be aware of needs, and professionals must be aware of new developments. The public must be kept informed in order to support local action, and public officials must be kept informed in order to take leadership. No single administrative mechanism or agency can provide all the necessary charnels for disseminating information on earthquake hazards. There are many existing capabilities that can be used for transmitting earthquake information; the extensive information and education programs of the Department of Agriculture are but one example. Examples of existing mechanisms for transmitting technical data and information include the National Technical Information **Service and** Environment Data Service of the Department of Commerce and the publication program of the U.S. Geological Survey.

All Federal agencies implementing actions or supporting research must communicate with those affected of their actions and the results of their work. It will be the role of the lead agency to monitor, and stimulate as needed, the flow of information among research workers, planners and designers, the construction industry, public officials, and the public. Communication with key groups in the society, particularly engineers architects, planners, and building and emergency **preparedness** officials is important: the development of earthquake hazards reduction training programs for these groups would be especially fruitful. Free flow of data and ideas among research workers is crucial to the success of the research program. The lead agency will seek to identify areas where communication among these groups can be strengthen and to effect it.

In carrying out its many functions the lead agency must be aware of new research results, the success or failure of various mitigation programs, and the status of all the earthquake hazard reduction actions throughout the Nation. To achieve this end it must develop mechanisms to allow for participation in and periodic review of its program by appropriate representatives of State and local governments, the public, and the professional and research communities. These mechanisms and other procedures for the dissemination of information will be included in the work plan to be prepared by the lead agency.

Expanding Understanding Through International Cooperation

The United States has neither the greatest nor the least exposure to earthquake hazards among the nations of the world. The frequent occurrence of destructive earthquakes around the world presents a two-fold humanitarian responsibility for the American people, first to assist in times of tragedy, and second to share information useful for mitigating the hazard. Lessons can be learned from earthquakes, foreign and domestic, that can be of value in mitigating hazards from future earthquakes. Several nations have earthquake research and hazard mitigation programs that are in some ways more advanced than those of the United States. Through continual and broadened cooperation with these nations we can learn much.

The Agency for International Development has a continuing responsibility to provide other nations and peoples with information that may help than moderate the impacts of earthquakes and to provide and coordinate Federal assistance when destructive earthquakes occur abroad. Several private professional organizations and Federal agencies have programs to study damaging earthquakes, both foreign and domestic. If gaps exist in the present programs, then the lead agency should identify them and assist in providing a means to fill them.

IMPROVING OUR KNOWLEDGE AND CAPABILITIES

In Fiscal Year 1978, the Nation embarked on a substantially increased program of research for earthquake prediction and hazards mitigation. This program, carried out by the U.S. Geological Survey and the National Science Foundation, is aimed at improving our fundamental capabilities to mitigate earthquake hazards. The full value of this program can be obtained only if it is continued at its present level of effort for several years, at least through Fiscal Year 1983. The main elements of the program are:

- Fundamental studies - research into the basic causes and mechanisms of earthquakes.
- Prediction - forecasting the time, place, magnitude and effects of an earthquake.

- Induced Seismicity - prevention or modification of an inadvertently induced or natural earthquake.

- Hazard Assessment - identification and analysis of the potential for earthquakes within a region, their frequency and their effects.

- Engineering - design and construction of structures for acceptable performance during and after an earthquake.

- Policy research - impacts of earthquakes on the community and options for dealing with them.

The technological base for mitigating earthquake hazards is far from complete. Some techniques, such as earthquake prediction and control, are still at an embryonic stage. In contrast, some techniques for earthquake hazard evaluation and engineering design have already been developed to a high degree but have not yet been applied to my hazard-prone regions. The delineation of active faults, for example, is a partially developed technique, the results of which are already being used as a basis for planning decisions. Because these techniques are in various stages of development, the results from research on earthquake prediction and hazards mitigation will become available on a variety of time scales.

Several other Federal agencies have ongoing research or service programs which, in addition to the programs aimed at the application of results discussed below, contribute to an understanding of the fundamental problems related to earthquakes. Examples include the geodetic survey and data service programs of the National Oceanic and Atmospheric Administration, the space geodesy program of the National Aeronautics and Space Ministration, seismology programs of the Department of Defense, and programs of the Nuclear Regulatory Commission and the Department of Energy, among others.

Effective application of the emerging results from the research programs of the Geological Survey, the National Science Foundation and other Federal agencies will require development of capabilities through applied research and development in a number of mission agencies. Opportunities for improving capabilities for utilization in these agencies must be identified and considered, and programs of applied research selectively reinforced to ensure the effectiveness of the actions for earthquake hazards reduction taken by the respective agencies. Examples of the kind of applied research required may include the improvement, development, and testing of earthquake design provisions for complex structures other than buildings, such as bridges, dams, tunnels, reactors, and other facilities. The lead agency will play a key role in working with the agencies to identify these opportunities and in developing an overview of the entire program. In addition, the research program will be periodically reviewed by the Office of Science and Technology Policy.

ECONOMIC, FINANCIAL, AND BUDGETARY CONSIDERATIONS

The objectives of the National Earthquake Hazards Reduction Program and the tasks developed to achieve them provide a basis for actions that will reduce loss of life and maintain the functioning of the economy in the event of an earthquake. The challenge before us is to foster policies that rationally and equitably assess the importance of earthquake impacts in relation to the benefits of carpeting economic and social allocations of resources. The incremental costs in future construction to accomodate the appropriate seismic resistant requirements is very small in comparison with the cost of correcting *past* deficiencies. As mentioned above, the cost of retrofitting even Federal buildings alone – not to mention others – would be astronomical. Through the coming decades many hazardous buildings will be replaced in the natural course of events by buildings built to modern earthquake resistant standards, **because the** older buildings have finished their useful lives. These two considerations – astronomical costs of retrofitting whole classes of buildings, *on the* one hand, and the normal, gradual replacement of hazardous buildings, on the other – illustrate the need for an evolutionary strategy based on the identification and the mitigation of the highest risks – those risks judged to be unacceptable. The unacceptable risk concerns the functioning of the economy. There must be no question that the economic and financial system will survive a catastrophic earthquake. But in our definition of 'unacceptable risk" the overall budgetary picture must be kept sharply in focus.

The program set out here attempts throughout to balance overall economic priorities. We, **as** a Nation, currently face substantial loss of life and property should a large earthquake occur today. The Program described here will not reduce the risk overnight. That cost would be unacceptable. Instead the Program attempts to identify those risks that are simply unacceptable, to eliminate those, and to work gradually through time to achieve a National posture in which we are less and less susceptible to the threat of earthquakes. This Federal program is best approached on a time scale of decades at a reasoned level, rather than at a high rest, crash effort out of proportion with the extent and immediacy of the problem. Several difficult financial problems about earthquake hazards and their reduction remain unsolved. The lead agency will undertake studies to examine these problems, including:

- Develop means to ensure a viable financial system in the event of a truly catastrophic earthquake. Preparations are currently made to ensure the viability of the financial system in the face of disasters such as nuclear attack. If a catastrophic earthquake would present different problems, these must be identified and appropriate preparations must be made.

- Understand the impact of an earthquake prediction on financial institutions and private investment. A credible earthquake

prediction made several ninths or more in advance of the predicted event might lead to severe stresses in the financial and investment systems. The nature of these stresses must be identified so that remedies can be devised in advance.

0 Explore the utilization of financial mechanisms within the public and private sectors, including Federal loan, loan-guarantee and grant programs, to effect earthquake hazards reduction. Although significant leverage for mitigation actions exist through these mechanisms, a potential for *serious* dislocation also exists. Consequently, a cautious, studied approach is required.

Assisting the lead agency in these studies will be the Federal Preparedness Agency and the Department Of the Treasury. Assistance will also be requested from the Federal Reserve Board, Federal Home Loan Bank Board, Federal Deposit Insurance Corporation, Farmer's Home Administration, Federal Insurance Administration, the HUD Office of Housing, and the Small Business Administration. The result of these studies will be available by March 1980.

The role of insurance as a means to compensate victims and encourage earthquake mitigation is potentially great. While residential and commercial earthquake insurance is currently available, it is not widely purchased. Serious questions exist abut the capacity of the insurance industry alone to absorb the cost of a catastrophic earthquake if such insurance were widely purchased. The Federal Insurance Ministration, in cooperation with the lead agency and other appropriate agencies, will undertake a study of earthquake insurance.

Federal expenditures for earthquake hazards reduction must be weighed carefully and balanced against competing national needs. The highest priority tasks, defined by their ability to effect *a* reduction in the problem areas that present the greatest risk, will receive the principal budgetary attention.

The lead agency will assist the Office Of Management and Budget in reviewing budgets for earthquake related matters. Coodinative mechanism to accomplish this effort till be identified in the work plan that will be prepared. In general, however, the allocation of the resources to undertake efforts in the earthquake hazards reduction field that fall within the mission responsibilities of each agency will be considered along with that agency's budget. The Office will be concerned primarily with questions of overall balance, prevention of duplication, and filling of gaps. The Federal program will be balanced and strive to allocate neither too little nor too much to earthquake hazards reduction and

will adapt to developments in research and experience. The first task in this regard will be to address the Fiscal 1980 budgetary requirements for priority actions established in this plan.

RESPONSIBILITIES FOR IMPLEMENTING THE PROGRAM

Responsibilities for implementing the Earthquake Hazards Reduction Program are shared among Federal, State, and local government and diverse groups within the private sector. The Program identifies the roles and responsibilities for Federal agencies and recommends the appropriate roles for State and local government and the private sector as follows:

Federal Responsibilities

A central focus for leading and coordinating the National Earthquake Hazards Reduction program is needed. Currently the President's Reorganization Project is considering options for the organization of the Federal activities in disaster mitigation and response. Pending decisions resulting from this study, a lead agency will be named. This will be accomplished within 300 days from the date of enactment of the Earthquake Hazards Reduction Act of 1977.

The principal roles and responsibilities of the lead agency include:

- o Stimulate and coordinate actions to reduce earthquake hazards within the Federal Government and throughout the Nation.
- o Provide leadership of the Federal Interagency Committee on Seismic Safety in Construction to:
  - – develop seismic design and construction standards for Federal projects;
  - – develop guidelines to ensure serviceability following an earthquake of vital facilities constructed or financed by the Federal government;
  - – develop guidelines that provide for independent and State and local review of seismic considerations in the construction of critical facilities constructed and financed by the Federal government, where appropriate

- Develop guidelines for the inclusion of earthquake hazards reduction activities in ongoing Federal programs.

- Develop a strategy to identify existing Federal buildings and other structues that pose unacceptable earthquake related risks.

- Coordinate the development of guidelines for the consideration of seismic risk in the development of Federals lands.

- Maintain liaison on earthquake-related matters with regulatory agencies such as the Nuclear Regulatory Commission and the Federal Energy Regulatory Commission.

- Develop mechanisms for the participation in and perodic review of the National program by appropriate representatives of State and local governments, the public, and professional and research communities.

- Review and update periodically the research and implementation plans to assure that they reflect the latest developments and objectives.

- Prepare and submit an annual report on the National Earthquake Hazards Reduction program to the president for transmittal to Congress.

The principal roles and responsibilities for the Federal agencies as they relate to this program include:

Office of Science and Technology Policy

- Review periodically the research program.

Department of Agriculture

- Participate through the Federal Interagency Committee on Seismic Safety in instruction to develop seismic design and construction standards for Federal projects and related guidelines.

- Work with professional organizations, model code groups, and State and local officials to establish appropriate local seismic requirements to be followed in Federal aid, grant, and loan programs.

- participate in the development of guidelines for the consider-tion of seismic risk in the development of Federal lands.

- Assist in the dissemination of information about earthquake hazards reduction activities through existing channels within the agencies of the Department.

Department of Commerce

o National Bureau of Standards

– Assist and cooperate with the Department of Housing and Urban Development, other Federal agencies (particularly those involved in research), National Institute of Building Sciences, professional organizations, model code groups, and State and local building departments, in continuing the development, testing, and improvement of model seismic design and construction provisions suitable for incorporation in local codes, standards, and practices.

– Research on performance criteria and supporting measurement technology for earthquake resistant construction.

o National Oceanic and Atmospheric Administration

— Operate the tsunami warning network and issue tsunami warnings.

— Cod.let geodetic surveys through the National Geodetic Survey.

— Provide data to researchers and the public through the Environmental Data Service.

Department of Defense

o Participate in the Federal Interagency Committee on Seismic Safety in Construction to develop-seismic design and construction standards for Federal projects and related guidelines.

0 Work with the lead agency and other Federal agencies in developing and testing a strategy to identify Federal structures that pose unacceptable seismic risks.

0 Initiate corrective action where existing agency facilities pose unacceptable seismic risks.

0 Corps ofEngineers

Participate in the Federal Interagency Committee on Seismic Safety in Construction to develop-seismic design and construction standards for Federal projects and related guidelines.

— Assess potential vulnerability of selected non-Federal dams to earthquakes and develop recommendations for additional seismic investigations as required.

— Participate in the development of guidelines for the consideration of seismic risk in the development of Federal lands.

Department of Energy

- o Participate in the Federal Interagency Committee on Seismic Safety in Construction to develop seismic design and construction standards for Federal projects and related guidelines.

- o participate in the development of guidelines for the consideration of seismic risk in the development of Federal lands.

Department of Housing and Urban Development

- o Participate in the Federal Interagency Committee on Seismic Safety in Construction to develop seismic design and instruction standards for Federal projects and related guidelines.

- 0 Work with Federdal research activities, professional organizations, model code groups, and State,and local officials and planners to establish appropriate local seismic requirement guidelines to be follow in Federal aid, grant, and loan programs.

- 0 Cooperate with other Federal agencies, State and local governments, and private sector agencies in the conduct of appropriate research to improve building codes and other mitigation measures.

- o Federal Disaster Assistance" Administration

  — Prepare Federa; earthquake contingency plans and assist State and local governments in the preparation of their plans.

- o Federal Insurance Administration

  – Undertake a study of the appropriate role of insurance in mitigating the impactS of earthquakes.

Department of Interior

- o Participate in the development of guidelines for the consideration of seismic risk in the development of Federal lands.

- o Bureau of Reclamation

  – Participate in the Federal Interagency Committee on Seismic Safety in instruction to develop seismic design and construction standards for Federal projects and related guidelines.

o Geological Survey

Conduct research on the nature of earthquakes, earthquake prediction, hazards evaluation and delineation, and induced seismicity.

Evaluate, with the advice of National Earthquake Prediction Evaluation Council, earthquake predictions.

Prepare national seismic risk maps.

Evaluate and delineate earthquake hazards on a regional basis.

Provide data and information on earthquake occurrences and hazards.

Department of State

o Agency for International Development

– Coordinate *assistance to* other nations stricken by earthquake disaster.

– Coordinate assistance to other nations in developing stragegies for mitigating earthquake hazards.

Department of Transportation

o Participate through the Federal Interagency Committee on Seismic Safety in Construction to develop seismic design and construction standards for Federal projects and related guidelines.

0 Work with the lead agency and other Federal agencies in developing a strategy to identify Federal structures that pose unacceptable. *seismic* risks.

0 Initiate corrective action where existing agency facilities pose unacceptable seismic risks.

0 Work with professional associations, model code groups, and State and local officials to establish appropriate local seismic requirements to be followed in Federal aid and grant programs.

0 Cooperate with other Federal, State, and private agencies in the conduct of appropriate research to provide an adequate technological base for standards for projects, such as bridges and tunnels, not covered by common building codes.

Independent Agencies

General Services Administration

- Participate in the Federal Interagency Committee on Seismic Safety in Construction to develop seismic design and construction standards for Federal projects and related guidelines.
- Work with the lead agency and other Federal agencies in developing a strategy to identify Federal structures that pose unacceptable seismic risks.
- Test and improve the strategy for identifying potentially hazardous Federal structures.
- Initiate corrective action where existing agency facilities pose unacceptable seismic risks.
- Develop guidelines for consideration of seismic hazard in the leasing of buildings.
- Federal Preparedness Agency
  - Assist in the studies of financial problems related to earthquakes.

National Science Foundation

- Support fundamental research studies on earthquakes, and basic and applied research on earthquake engineering and policy.

Veterans Administration

- Participate in the Federal Interagency Committee on Seismic Safety in Construction to develop design and instruction standards.
- Work with the lead agency and other Federal agencies in developing a strategy to identify Federal structures that pose unacceptable seismic risks.

The discharge of these responsibilities by the above principal agencies will require the participation, assistance, and cooperation of many agencies and units of the Federal Government: among these are:

Small Business Administration
Nuclear Regulatory Commission
Environmental Protection Agency
Department of Health, Education and Welfare
National Aeronautics and Space Administration
Department of Treasury

These agencies and others as identified by the lead agency will assist it and the agencies with principal responsibilities to achieve the purpose of this plan.

Under existing authority, many Federal agencies have important responsibilities for design and construction or for emergency preparedness, response, and relief. These responsibilities will continue undiminished. Where deficiencies are identified, steps will be taken to remedy them. Most Federal responsibilities described under this program can be carried out under existing legislative authority or by executive assignment. Should specific needs for additional legislation to implement this Program be identified, these needs will be communicated to the Congress.

State and Local Responsibilities

State and local governments bar the responsibilities for preparedness, response, warning, regulating construction, and regulating the use of land. The National Earthquake Hazards Reduction Program must, to be successful, include the development of State and local strategies for defining and meeting their responsibilities in earthquake hazards mitigation.

The most severely threatened States need to analyze their own problems **and** find their own solutions. This process should include the modification of decision making processes to include considerations of earthquake hazards where appropriate. Many sources of funds are available to States, local governments, and the private sector through Federal aid, grant, loan, and loan guarantee programs. Most of these Federal programs base their requirements for earthquake considerations on local codes and regulations. Rather than impose universal standards on local governments, it is more appropriate for the Federal agencies supplying the aid, grants, loans, and loan guarantees to work with professional organizations and State and local officials to encourage the development and adoption of appropriate seismic provisions in local codes. States need to assess their current posture and to identify opportunities to reduce their exposure to hazards through modification of existing procedures or regulations. Under existing authority and regulations there are several Federal aid programs that can be used, at the option of the recipient, to mitigate earthquake hazards. The example is the Community Development Block Grant Program, which can be used for a variety of mitigation measures, in many instances, including the acquisition of lands or facilities in seismic hazard zones, identification and mapping of local hazard zones for land use planning, and retrofitttig, razing or relocation of structures.

One area of particular concern to State and local government is how, in the future, to respond to an earthquake prediction. Effective utilization of a scientifically credible earthquake prediction for the good of the public will depend on the kinds and extent of defensive action taken in response to the prediction. The responsibilities to warn the people about imminent danger from a nature hazard and to direct then on how to take defensive action are principally State and local government functions, assisted as appropriate by the Federal

government. The responsibility for the declaration of an 'emergency" after an earthquake prediction rests with the Governor of a potentially affected State. He may also request the declaration of an "emergency" or a major disaster" by the President, according to the provisions of the 'Disaster Relief Act of 1974" (P.L. 93-288). If the President accedes to this request, Federal agencies will then initiate appropriate actions under this Act. The States should review existing legislation defining the responsibility and liability of Governors other officials in regard to the evaluation of predictions and issuance of warnings, and take steps to remedy any existing deficiencies. In some cases this is already underway.

The opportunity exists for State and local governments to mandate, through legislation, including the adoption of building codes and zoning ordinances, earthquake hazards reduction actions on private property. *Much* has already been said about the importance of State and local codes and stardards for the construction of buildings resistant to earthquakes. In the rapidly urbanizing areas of the country susceptible to earthquakes, regulation of land use through building codes or local zoning is the most effective way to avoid some earthquake hazards. The people of California, through the adoption of a variety of State and local regulations, have provided outstanding, if not universally applicable examples of what can be done. The State Planning Law requires a "Seismic Safety Element" as a part of the General Plan of each city and county. The Alquist-Priola Geologic Hazards Zones Act requires the State Geologist to delineate zones along active faults in which special geologic studies must be carried out prior to development. The Field Act, passed following the collapse of **several** schools during the *1933* Long Beach earthquake, has been extremely successful in improving the design and instruction of-schools to resist earthquakes, as most recently demonstrated by the performance of school buildings during the 1971 San Fernado earthquake.

In California local communities have also played a strong role. The seismic provisions in the building codes in some California communities provide examples for other parts of the country with high seismic risk. The ordinances enacted by some local communities to reduce the hazards from parapets, a major life hazard should debris from parapets fall onto a crowded street below, demonstrate what can be done by communities who face their earthquake problems squarely. But appropriate application of the California experience in other seismically active parts of the country cannot be mandated by Federal fiat. State and local action is required. The identification of opportunities for State and local governments to mandate hazards reduction and the decision to act on these opportunities requires the leadership of State and local officials and the resolve of the citizenry.

The local, State, and Federal roles in earthquake hazards reduction are strongly interrelated. The Federal government has important roles in supporting State and local efforts through the provision of information, the development of guidelines and standards for some facilities, encouragment, and financial support as described earlier. To achieve overall earthquake hazards reduction the State and local governments must identify and address their own local earthquake problems.

Private Responsibilities

As can be seen by many key points in this Program, the success of a national effort to mitigate losses and suffering from earthquakes rests largely in private hands. The role of the Federal government is limited as are the roles of State and local governments.

Business, industry, and the services sector play the lead roles in constructing new buildings and in developing land. Seismic design provisions in local codes, be they modern or outdated, are minimum standards. Thoughtful businessmen interested in providing a safe environment for their consumers and employees, and in protecting their capital investment will want to give careful consideration to earthquake hazards in planning, constructing and maintaining their facilities. The *success* of much of this program requires the leadership of these elements of the private sector. The interest of business and industry must be maintained in order to accomplish our objectives. In some instances short-term profits may be *reduced* to increase the long-term benefits of saving lives, reducing property damage, and maintaining the functioning of the economy in the face of a major earthquake. Private financial institutions, including lending agencies and insurance canpanies, must continue their important role. These institutions may identify opportunities to effect hazards reduction that can be beneficial to all concerned.

Voluntary organizations have traditionally played a major part in providing specialized assistance to victims of disasters. The Nation places continuing reliance on the efforts of these citizens. Opportunities exist for these same organizations to provide even greater public service by initiating actions to mitigate losses before the disaster, particularly through the disseminationof information. This capacity will be even more important as the ability to predict earthquakes develops. Money and people do not add up to capability. What is required is the development of interest, experience and expertise.

Individuals and organizations from the research and professional communities, especially practicing professionals, have developed the degree of awareness of earthquake hazards that we have today. Government must work to assist, rather than replace, these efforts. Professional organizations have a continuing and vital role to play. The improvement of model codes, their testing, and their adoption by State and local governments require the vigorous participation of the professional community. Of course any code is only as good as the practice used to carry it out. High quality workmanship and improving practice are responsibilities shared by all elements of the construction industry and local building officials.

The professional organizations also have a particularly important part in communication the the exchange of information. Opportunities for training programs focused on techniques for earthquake hazards reduction should be identified and carried out through these organizations.

Ultimately the success or failure of the National Earthquake Hazards Reduction Program will depend on the resolve of the American people, particularly in the private sector. The expenditure of dollars does not make a successful program. The enthusiasm, the expertise, the willingness to work, and the perseverance of the people are required to make the program effective.

CONCLUSION

A reduction of the earthquake hazards faced by the Nation cannot be achieved overnight — or even in a few years. It will require continuing effort on the part of many individuals and institutions in government, and the private sector. Many actions can be taken today. Other actions must await the outcome of research. The reduction of earthquake hazards has an important place among our national priorities, and we must begin now. The National Program for Earthquake Hazards Reduction outlines an aggressive program to reduce these hazards — a program that is balanced against our other national needs and is responsive to the intent of Congress.