LAND USE PLANNING AFTER EARTHQUAKES[1]

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This study has two objectives: 1) to determine why land use planning after earthquakes has not been more effective as a method of reducing seismic risk, and 2) to recommend ways to improve post-earthquake land use planning. The study stems from observations that typically little attention has been given to avoiding or restricting development or reconstruction in areas revealed by an earthquake as especially hazardous. An underlying concept of this project is that well-planned land use changes following an earthquake can effectively reduce risk from future earthquakes. Possible land use responses include changes in land use plans and regulations, changes in land use or occupancy, relocation of facilities, redevelopment, and land acquisition. Furthermore, it is believed that planning for reconstruction can take place without unreasonable delay or hardship.

Of course, many pressures foster rebuilding as rapidly as possible and tend to ignore longer-range land use planning issues. Quite naturally, the prevailing attitude after an earthquake is a desire to help those who have suffered injuries, disruption of their lives, and property damage. Given this attitude, actions to reduce future risk can be seen as interfering with rapid recovery. The overriding concern is with immediate needs, not with future disasters.

In addition, land use planning has tended to be ignored because of an emphasis on improving safety by rebuilding and repairing structures to withstand shaking better. Also, operating against effective land use planning after earthquakes is the very nature of land use changes--changes which can dramatically affect the value of land and are therefore politically very sensitive. Nonetheless, the potential role of land use planning after earthquakes is seen as very significant and worthy of investigation.

To deal with the questions relevant to post-earthquake land use planning, case studies of reconstruction after three recent U.S. earthquakes formed the major research base. The three case studies were selected to illustrate as broad a range of earthquake effects and response as possible. The selection of these earthquakes made it possible to interview people who participated in the post-earthquake reconstruction efforts, gave reasonable assurance that information on geologic and seismic effects and structural damage was at or close to the state-of-the-art, and set the investigations in the context of modern planning practices and procedures. In fact, the choice was very limited. From 1959 to 1978, eleven earthquakes occurred in the United States which

caused damage in excess of $1 million (dollars at the time of the earthquake). Of these, only three (Alaska 1964, Puget Sound 1965, and San Fernando 1971) were federally-declared major disasters.

As by far the largest and best documented recent earthquakes, Alaska and San Fernando were obvious choices for study. In addition, Santa Rosa, 1969, was chosen because of the interesting local effort to abate existing structural hazards throughout the city after the earthquake. For each case, the project team reviewed available background material related to the earthquake, geologic and structural effects, and reconstruction efforts. Key people involved with the reconstruction were then interviewed to learn further what actions were taken and, to the extent possible, the factors that influenced the decisions made.

Reconstruction experience following selected other domestic and foreign earthquakes and natural disasters was reviewed and summarized. This part of the study involved reviewing published accounts and other records of reconstruction following the tornadoes in Xenia, Ohio in 1974 and Omaha, Nebraska in 1975; the flood in Rapid City, South Dakota in 1972; the tsunami in Hilo, Hawaii in 1960; and the earthquakes in Managua, Nicaragua in 1972 and Skopje, Yugoslavia in 1963. In addition, the Bluebird Canyon landslide of October 1978 in Laguna Beach, California was studied and revealed valuable lessons. The information was used to confirm or to raise questions about conclusions from the detailed case studies and to explore possible similarities between reconstruction problems after earthquakes and other disasters.

To investigate the problems and potentials of post-earthquake land use planning an interdisciplinary research team was formed. The team included members from the firms of Earth Sciences Associates, a geotechnical firm, H.J. Degenkolb and Associates, structural engineers, and William Spangle and Associates, Inc., city and regional planners. In addition, special consultants in public administration and law were retained.

A Discussion Group Panel composed of recognized experts in various aspects of post-disaster response was organized and met with the study team four times during the two-year study providing comments on the work program, case study reports, and the conclusions and recommendations emerging from the study. After completing the case studies, the project team assembled the comments of the Discussion Group Panel and other reviewers of the case study reports, reviewed the material on other earthquakes and disasters, and reassessed the conclusions and recommendations drawn from the case studies. From this evaluation, recommendations were developed for improving post-earthquake reconstruction, particularly with respect to land use planning.

The project team recognizes that the three case studies are a small sample to illustrate the wide variety of possible conditions and problems pertaining to post-earthquake reconstruction. However, common threads are identified and reinforced by the review of reconstruction following other natural disasters and earthquakes. These commonalities form the basis for the conclusions and recommendations to improve post-earthquake land use planning.

Major Factors Affecting Post-Earthquake Land Use Planning

A central objective of this study has been to identify the factors influencing land use decisions following a damaging earthquake. A key finding is that realistic options for land use change after an earthquke are more limited than the study team expected at the outset of the study. Usually improved safety can be more easily achieved through improved structural design and construction than through changing land use. However, in specific instances, changing land use is the best response. The major findings regarding whether land use changes are appropriate and likely to be carried out can be grouped under four headings:

- cause and extent of damage
- hazard and risk evaluation
- capabilities of local government
- role of the federal government

Cause and Extent of Damage

The need for land use change following an earthquake depends, in part, on the cause and extent of damage. Rarely, if ever, will a U.S. city be leveled; areas are not equally hazardous and most damage is likely to be scattered. Every major earthquake seems to yield its photograph of the totally collapsed building next to a seemingly similar one standing unscathed. The greatest loss of life, injury and property damage in North American earthquakes result from the failure of man-made structures. Most structural failures are caused by ground shaking and the results can be extraordinarily capricious, related in some degree to variations in ground conditions, but more importantly, to building design and condition. In addition, different earthquakes produce different ground shaking characteristics such as intensity, predominant frequency, and duration of motion, which result in correspondingly different effects on different types of structures. Damage from ground shaking alone rarely justifies a change in land use, because improving structural design and construction can usually reduce risk to an acceptable level.

An exception arises when heavy damage from ground shaking is concentrated in areas of older and poorly constructed buildings, particularly where unreinforced masonry is a widely used building material. Often such areas are deteriorating, functionally obsolescent, and in need of redevelopment before an earthquake. The earthquake presents the chance to move ahead with redevelopment as an integral part of reconsruction. However, even in such cases, reducing seismic risk is usually achieved through improvements in structual characteristics and not necessarily because of changes to less vulnerable land uses or occupancies.

Land use change is most likely to be appropriate in areas where ground failure has occurred, whether from surface fault rupture, landsliding, soil liquefaction, or other causes, and in areas where flooding has occurred, whether from seiche or tsunami runup or dam or dike failure. Achieving reasonably safe reconstruction in such areas is often difficult and usually expensive. Where there is a high risk of future ground movement, either the area must be stablized to prevent further movement or structures must be designed and constructed to overcome adverse site conditions. Adequate protection against future flood damage requires construction of flood control works, flood-proofing

or elevation of structures. In both cases, restricting land use and occupancy may be the most economical and effective method of reducing future risk.

Changing land uses in areas of ground failure and flooding may not only reduce future seismic risk, but also contribute to other community objectives. Ground failure often occurs in steep hillsides, on coastal bluffs, and in low-lying areas along rivers, streams, lakes, and other bodies of water. Low-lying areas may also be subject to flooding. These areas can often be beneficially used for park, or other low-intensity open space uses. Some seismically hazardous areas may also be subject to other natural hazards such as wild fires, high winds, non-seismic flooding, or storm surges. Reducing intensity of land use in these areas after a damaging earthquake may not only avert future needs for disaster assistance because of earthquake damage, but also reduce exposure to damage from other natural hazards.

Hazard and Risk Evaluation

Efforts to reduce risk from natural hazards through land use planning and regulation depend on the ability to delineate hazardous areas and evaluate the level of risk pertaining to potential uses in those areas. Delineating hazardous areas is often easier after an earthquake than before. For example, it is possible to delineate areas where the ground failed, flooding occurred, a fault ruptured at the surface, and ground shaking was unusually intense or damaging. In all of the earthquakes studied, hazardous areas were readily identified in studies made soon after the earthquake. The most systematic hazard evaluation after a U.S. earthquake was that conducted by the federal Scientific and Engineering Task Force after the Alaska earthquake.

Although delineating hazardous areas after an earthquake is fairly readily accomplished, evaluating risk is far more difficult. Risk is exposure to loss of life, injury and property damage. Its level depends on the probability of a hazard recurring and the use and occupancy of the hazardous area.

In the cases studied, risk was assessed by engineers. In San Fernando, risk was explicitly considered in the structural design for rebuilding Juvenile Hall and Olive View Hospital. The objective was to design buildings to overcome hazardous site conditions and to meet commonly accepted engineering standards for the safety of high-occupancy and critical structures. In Alaska, the Scientific and Engineering Task Force delineated hazardous areas, determined that the areas could be unstable in future earthquakes and made recommendations for stabilization and/or use limitations to reduce risk. No explicit consideration was given to the probability of recurrence and risk was expressed in relative terms (high risk, nominal risk, etc.). Explicit assessment of risk was made by engineers in the design of the Fourth Avenue buttress and in the development of specific building restrictions.

A determination of risk expressed as the annual probability of loss of life, injury, or damage is unlikely to be available after an earthquake to guide land use decisions. However, decisions will still be

made and should be based on the best information and professional judgment available. Information regarding the level of risk can significantly help public decision makers make the necessary value judgments concerning the acceptable level of risk.

It would be helpful to have some standard or guideline as to acceptable risk, such as the 100 year flood standard, to serve as a basis for federal decisions to fund reconstruction projects. It is not likely that as specific a standard for acceptable earthquake risk can be set. The many variables affecting acceptable risk make wide agreement very doubtful.

Improved techniques of hazard evaluation and risk assessment, including advances in earthquake prediction, will help in making decisions. As presently defined by the earthquake reseach community, an earthquake prediction reduces uncertainty about when an earthquake can be expected and its location and magnitude. This allows more precise definition of risk in areas known to be hazardous and more accurate assessment of the benefits or results of public actions to reduce those risks. Still, for the foreseeable future, except in the area of structural standards, federal funding decisions will likely have to be based on imprecise judgments of risk.

Capabilities of Local Government

Through grants of authority from the states, local governments appear to have adequate authority under the police power to respond to a damaging earthquake. However, local public attitudes may strongly inhibit the full use of this authority, especially to plan and regulate land use. After an earthquake (or other disaster) local public officials and political bodies are understandably anxious to do everything possible to help disaster victims. Although local government has the power to impose limitations on rebuilding in hazardous areas, public sentiment, in the absence of adequate public information and strong leadership, is more likely to favor relaxing restrictions rather than increasing them. The desire to return quickly to normal usually overrides concerns about future safety unless strong incentives for change are present. These incentives are usually of two kinds--first, strongly held community objectives which are consistent with actions to reduce seismic risk, and second, conditions attached to the use of disaster relief funds. Understanding community objectives helps predict where changes to achieve risk reduction are likely to be most acceptable to a local community. The use of disaster relief funds offers the major opportunity to accomplish greater safety through reconstruction.

The post-earthquake performance of local government is largely determined by pre-earthquake actions. If a community has acted before an earthquake to adopt and enforce adequate building codes, abate structural hazards, locate critical facilities on safe sites, and prevent or appropriately control development in hazardous areas, then clearly it will suffer less damage and face less of a problem in recovery after an earthquake. These actions are of primary concern and have been gradually taken by many local governments. Less obvious are the pre-earthquake actions which, although they do not in themselves reduce damage from the next earthquake, assist a local government in managing reconstruction. The actions include:

1. preparing and keeping up-to-date realistic land use, circulation, and public facilities plans. The community which has a well-established planning function, experienced planners, and realistic plans is more likely to recognize and seize opportunities for community improvements during reconstruction than other communities. Having well-defined community development objectives helps federal, state, and local officials set reconstruction priorities and judge the public acceptability of potential land use changes or restrictions.

2. enacting and enforcing land use regulations, building codes, and project review procedures. Experience in plan implementation and appreciation of the importance of consistent and equitably applied regulations can help a local government cope with the usual overload in building permit applications, requests for exemptions, and pressures to alter established procedures after an earthquake.

3. establishing a redevelopment agency and carrying out redevelopment or rehabilitation projects. Such experience is invaluable after an earthquake if redevelopment is to be used in reconstruction. Pre-existing powers and familiarity with techniques of redevelopment planning, project execution, and funding requirements make it easier for a local agency to use redevelopment in reconstruction after an earthquake. A community with up-to-date redevelopment plans or specific plans for older areas likely to be damaged in an earthquake is in an excellent position to move quickly into redevelopment, if needed, after the earthquake.

4. obtaining and using geologic and other natural hazard related information. Familiarity with the techniques and products of hazard evaluation will greatly assist the local government staff and public officials in making use of the technical information that will be forthcoming after a major earthquake. Less time will be needed to explain the nature of seismic hazards and the range of appropriate responses.

The effectiveness of local response will also be affected by factors such as the size of community, degree of isolation, existing land use pattern, economic health, and a variety of social and cultural factors. These are factors that cannot be readily altered before a disaster, but which help define the options and problems of reconstruction. Changes of land use may be more difficult to achieve in a large metropolitan area with its complex and interdependent land uses and infrastructure than in a relatively small and isolated community. Opportunity for major relocation of all or part of a community is greater if the community is small and isolated than if it is an integral part of a metropolitan area. Isolation implies vacant land that may be available for relocation and the chance to contain the disrupting impacts of relocation. Relocation was a feasible option for the town of Valdez after the 1964 earthquake and for a portion of Hilo after the 1960 tsunami. The impacts of large-scale relocation multiply with the size of the community and its degree of interdependence with surrounding communities.

The existing land use pattern, largely determined by local actions, is very important in defining options for land use change after an earthquake. The feasibility of relocating uses or structures is affected by the availability of suitable alternative sites and by the presence of

reasonable alternative uses for the damaged site. The possible cost of engineered solutions to hazardous site conditions has to be weighted in terms of the importance of the location for a particular use or structure and realistic options for changing location.

A community with a growing economy may even benefit economically in the long run from a damaging earthquake with the stimulation provided by federal disaster relief funds, increased construction activity, and, sometimes, the modernization of previously obsolete industrial and commercial operations. The fish processing plants destroyed in the Alaska earthquakes were replaced by more modern and efficient facilities.

The effect of economic conditions on opportunities for land use change after an earthquake is mixed. In a growing economy, political pressures and the economic means to reconstruct quickly can act against efforts to reduce land use intensity in hazardous areas. This is seen in the privately-funded recontruction and new high-density construction in the L Street slide area in Anchorage. In a declining economy, the private economic incentive to rebuild is far less intense. In Seward, where Standard Oil, Texaco, and a fish processor chose not to rebuild their destroyed facilities in the town, little economic pressure has developed for new building in the waterfront area. In spite of public investments in the Alaska Raiload terminal and small boat harbor, Seward's economy continues its pre-earthquake decline.

The Santa Rosa case illustrates another potential effect of economic conditions on response to an earthquake. The city's healthy and growing economy with concomitant increases in property values has made redevelopment an attractive and economically viable option and has provided a climate conducive to the abatement of structural hazards through privately-funded rehabilitation.

The contrast between the accomplishments of Anchorage and Santa Rosa, both with growing economies, illustrates an important point. With insufficient funds for stabilization or purchase of the L Street and Turnagain slide areas, Anchorage's only real option for reducing future risk was to prohibit or severely limit new development in these areas. In a growing economy with strong development pressures, this is difficult to achieve. In Santa Rosa, however, future risk could be reduced by gradually upgrading structural safety. This approach presents no direct challenge to development and can be aided rather than undermined by economic growth.

Role of the Federal Government

The major conclusion derived from the study is that the availability of, and conditions for the use of, federal funds for post-earthquake recovery largely determine the actions and decisions of local governments. Financing recovery from a major earthquake is likely to be beyond the fiscal capacity of state governments and almost certainly of the affected local governments. Private funds may be available for reconstruction of private property, but such reconstruction is often dependent on repair or restoration of public facilities, especially streets and utilities. Relatively few property owners carry earthquake insurance. The federal role in financing reconstruction has been crucial in past earthquakes and is likely to continue to be crucial in the foreseeable future.

The scope and limitations of federal aid to disaster victims and state and local governments are set forth in the Federal Disaster Relief Act of 1974 and regulations issued May 28, 1975. The major provisions of the Act are, as of July 1979, administered by the Federal Emergency Management Agency (FEMA). Observations of the strengths and weaknesses of the federal role under prior legislation has provided a basis for evaluating the adequacy of the present legislation and regulations as they apply to earthquake disasters. Seven problems are identified.

1. Lack of specific authorization and funding for redevelopment projects. Where used for reconstruction, publicly-funded redevelopment proved to be a particularly effective tool for achieving changes in land use and safe reconstruction in heavily damaged areas. However, current programs and funding for redevelopment following earthquakes is seen as inadequate. A special fund has been set aside for use at the discretion of the Secretary of Housing and Urban Development for disaster-related projects. However, the present appropriation is a small percentage of this discretionary fund and likely to be inadequate to cover needed projects following a major earthquake in a metropolitan area.

2. Lack of requirements, procedures, and funding for planning and implementing plans for long-term reconstruction. Title V of the Disaster Relief Act provides for establishment of a Recovery Planning Council to prepare a 5 year "recovery investment plan" recommending "revision, deletion, reprogramming, or additional approval of Federal-aid projects and programs within the area..." (Sec. 802). The main objective of the Title is to assist a disaster area in achieving long-term economic recovery. The Title has not been implemented and no federal agency has been assigned responsibility for carrying out its provisions. Title V imposes no planning requirement for use of federal funds in reconstruction of heavily damaged areas and fails to authorize funding for such planning and implementation of plans. Project applications for repair and reconstruction of public facilities are considered individually and there is no requirement for coordinating the restoration of public facilities and services with private repair and reconstruciton.

   In many of the U.S. communities studied, plans for reconstruction were quickly prepared after the disaster. Most of the plans were for redevelopment projects and dealt with the most severely damaged areas. Redevelopment plans for areas with hazardous site conditions effectively addressed those conditions. However, several problems were observed in the planning efforts: 1) Small Business Administration loans were often approved for repair or rebuilding of privately-owned structures without regard for planned uses or decisions of other federal agencies to fund rebuilding of public facilities, 2) limitations of federal funds for redevelopment led to restriction of the scope of some projects and abandonment of others, and 3) projects that required adoption of local land use and building regulations or acquisition of significant amounts of private property for public uses seemed to generate strong local opposition. There appears to be a need after a disaster, for preparation of a plan for long-term reconstruction, and also for procedures to ensure that federal and local decisions affecting rebuilding are consistent with the plan.

3. Disincentives for relocating public facilities or repairing and reconstructing facilites to improved standards not in force at the time of the earthquake. Section 2205.54 of the Rules and Regulations states that the federal contribution for permanent repair or restoration of public facilities "shall not exceed the net eligible cost of restoring a facility based on the pre-disaster design of such facility and on the current codes, specifications, and standards in use by the applicant for similar facilities in the locality." The regulations permit 100% federal funding for the repair or reconstruction of public facilities. The Regional Director of FEMA may authorize relocation of a facility to a less hazardous site; however, any additional cost must be borne by state or local government.

   The effect of this provision is to discourage relocation of damaged facilities to less hazardous sites unless suitable, publicly-owned sites are available. After a damaging earthquake, local governments rarely have the financial resources to purchase new sites for relocation of public facilities and the tendency is to seek engineering solutions to hazardous site problems with little consideration of possible advantages of relocation.

4. Lack of guidelines for determining price to be paid for properties to be acquired as part of a post-earthquake redevelopment project or a planned relocation. Establishing criteria for determining the price to be offered for properties to be acquired for public purposes after an earthquake is a major issue. In several cases studied, the failure to come to terms on property value resulted in rejection of projects which would have significantly improved future safety. Reasonable criteria for establishing compensation are needed. Property values after an earthquake are usually lower. A recurring question is to what extent an owner should be compensated for pre-earthquake value.

5. Little consideration of long-term hazard mitigation in administering disaster assistance. Although explicit consideration of hazard mitigation is required in Sec. 406 of the Act, no rules have been adopted to implement this section. Section 406 states:

   > As a further condition of any loan or grant made under the provisions of this Act, the State or local government shall agree that the natural hazards in the areas in which the proceeds of the grants or loans are to be used shall be evaluated and appropriate action shall be taken to mitigate such hazards, including safe land-use and construction practices, in accordance with the standards prescribed or approved by the President after adequate consultation with the appropriate elected officials of general purpose local governments, and the State shall furnish such evidence of compliance with this section as may be required by regulation.

   In April 1979, the Federal Disaster Assistance Administration, now the Office of Disaster Response and Recovery in FEMA, issued proposed rules for implementing this section of the Act following a major disaster declaration. The rules call for a Survey Team to be formed by Hazard Mitigation Coordinators (HMC's) from federal,

state, and local governments to identify significant hazards, evaluate the impacts of the hazards and possible mitigation measures, and recommend appropriate mitigation measures. The recommended measures would be required by FEMA as a condition of receiving federal funds, authorized under Sec. 402 of the Act, for the repair, restoration, reconstruction, or relocation of public facilities. The state would be responsible for verifying compliance of local governments with hazard mitigation requirements.

These proposed rules would help correct the lack of consideration of hazard mitigation in reconstruction decisions after natural disasters. Because of the importance of federal funds in post-earthquake reconstruction, the proposed federal requirements are likely to be particularly effective in encouraging safer reconstruction after earthquakes. However, local ability to meet hazard mitigation requirements after an earthquake is likely to depend on the availability of funds.

6. Lack of explicit consideration in administering disaster assistance of opportunities to achieve other federal community development objectives. Federal community development objectives as set forth in the Housing and Community Development Act of 1977 (Sec. 101) include:

   (1) the elimination of slums and blight,

   (2) the elimination of conditions which are detrimental to health, safety, and public welfare,

   (3) the conservation and expansion of the Nation's housing stock,

   (4) the expansion and improvement of the quantity and quality of the community services,

   (5) a more rational utilizaton of land and other natural resources,

   (6) the reduction of the isolation of income groups within communities and geographical areas,

   (7) the restoration and preservation of properties of special value for historic, architectural, or aesthetic reasons, and

   (8) the alleviation of physical and economic distress through the stimulation of private investment and community revitalization in areas with population outmigration or a stagnating or declining tax base.

Often after a major earthquake, reconstruction can be carried out in a way that significantly furthers one or more of these objecties, typically through redeveloment of heavily damaged areas. Such opportunities need to be considered in federal decisions to fund recovery projects. Successful projects are likely to be those clearly related to damaged areas and consistent with community needs and objectives. However, trying to accomplish too much or extending projects significantly beyond damaged areas is likely to be rejected

locally unless the public is convinced the projects will not interfere with the return to normal and will lead to substantial benefits. Some redevelopment (or development) projects may be needed to accommodate uses displaced from high hazard areas.

7. Lack of flexibility in administering disaster assistance sometimes leading to federal/local conflict. In spite of the presumably altruistic nature of disaster relief efforts, there are elements of conflict in the relationship between federal and local officials in the post-disaster situation. Local people are striving to maximize assistance to victims and local governmental agencies, while the federal officials are anxious to minimize the cost of relief, insure that funds are spent only for authorized purposes and avoid any possible irregularities that might bring criticism at a later date. Even when officials have broad authority, there is a tendency to interpret it narrowly. The effect of this conflict is to slow down the reconstruction effort and create uncertainties which can lead to private actions undercutting public attempts to reduce future risk. Procedures are needed to encourage sufficient flexibility in administering disaster assistance to take account of variations in local conditions and minimize chances for conflict.

Recommendations for Land Use Planning Following a Major Earthquake

Land use planning after a damaging earthquake can be an effective tool to reduce future seismic risk. It can and should be a significant part of the total intergovernmental response to a major earthquake. Presently, when a large damaging earthquake occurs, the governor of the affected state requests that the President of the United States declare a major disaster--by definition a catastrophe of such severity and magnitude that effective response is beyond the capability of the state and the affected local governments.

If the President declares a major disaster, a federal/state agreement, specifying the categories of federal assistance to be made available for recovery, is signed by federal and state representatives. Federal funds may be available for: temporary housing assistance, mortgage and rental payments, unemployment assistance, individual and family grants, food commodities, relocation assistance, emergency public transportation, repair and restoration of public (and certain private) facilities, debris clearance, and loans to cover substantial losses of local tax revenues. Less extensive assistance may be authorized for federally-declared "emergencies"--disasters of less severity and magnitude than the "major disasters."

The Presidential declaration formally inaugurates coordinated federal, state, and local efforts in response to a disaster. The organization and procedures governing these efforts are geared primarily to handling emergency response. However, there is a need for more explicit consideration of hazard mitigation in actions related to long-term recovery from major earthquakes. Thus, the recommendations are presented in the form of suggested federal regulations and procedures to incorporate hazard evaluation, land use planning for hazardous areas, and funding for plan implementation into the present framework for federal disaster assistance. State legislation and regulations may be needed to authorize the participation of state agencies and local governments in the activities recommended.

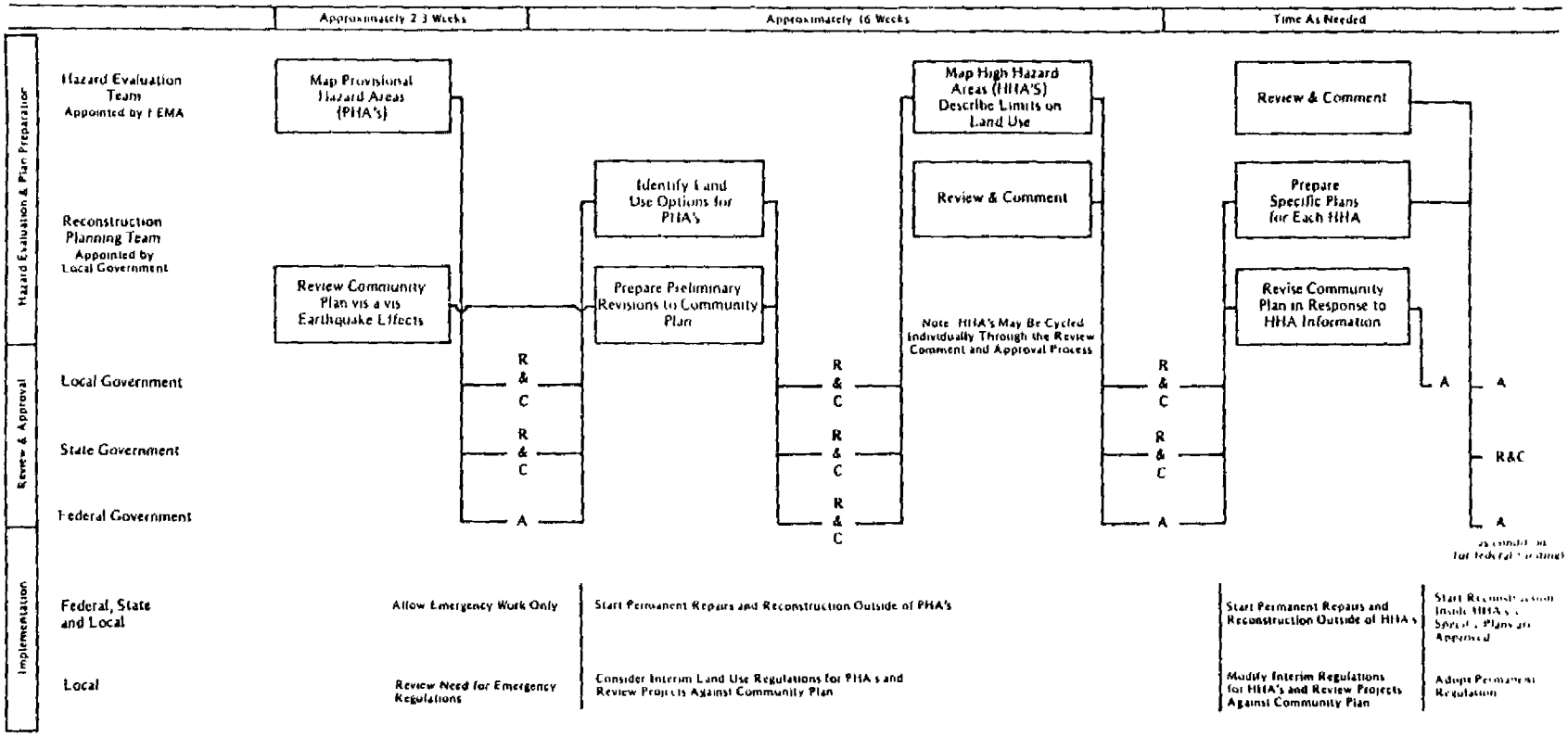
Figure 1 outlines the sequence and interrelationships of the governmental activities essential to land use planning in a post-earthquake context. The key functions, as shown on the left side of the diagram, are hazard evaluation and plan preparation, review and approval of maps and plans, and implementation of land use plans for hazardous areas. Figure 1 also shows the sequence of steps needed to provide hazard area information for use in preparing plans and for hazardous areas within the framework of a community-wide plan. As shown, the functions of hazard evaluation and reconstruction planning are interrelated, but, carried out by two teams which would work together during reconstruction. Procedures for review and approval and implementation actions are described for each map or plan which emerges from the actions shown in the figure.

Hazard Evaluation

The need for timely and credible evaluation of hazards after a damaging earthquake is clear. The function is viewed as essentially a federal responsibility to insure that federal funds for reconstruction are allocated in a way that reduces damage potential in future earthquakes and, in particular, reduces the likelihood of repeated federal assistance in areas which have already experienced earthquake damage.

Hazard Evaluation Team. Immediately after a major earthquake disaster is declared, the Director of the Federal Emergency Management Agency (FEMA) should appoint a Hazard Evaluation Team (HET). The purpose of the HET should be to provide scientific and technical information and recommendations needed to plan for the safe reuse or reconstruction of hazardous areas. Members of the HET should be selected from a list previously prepared by federal and state agencies and professional organizations. Professionals with experience in, and familiarity with, the local area should be included on the team. In most cases, the team would include geologists, engineering geologists, geotechnical engineers, structural engineers, and seismologists, but the composition should be determined by the characteristics of the earthquake hazards involved. Expenses of the team should be paid by FEMA.

Provisional Hazard Areas. Within two to three weeks of appointment, the HET should prepare a report including maps showing Provisional Hazard Areas (PHA's). PHA's should include areas of ground failure, flooding, and concentated structural damage. The PHA's should be drawn large enough so that refinement of data is more likely to result in a decrease in size than an increase. The report should describe the reasons for the designation of PHA's and recommend design and construction standards for federally-assisted repair and reconstruction throughout the earthquake damaged area. The report should be released simultaneously to the federal and state disaster relief personnel, officials of affected local governments, property owners, local financial institutions, and the news media for review and comment. Following approval of the maps and recommended standards by the Regional Director of FEMA, federal funds to assist property owners and public agencies with permanent repairs in areas outside the PHA's should be made available. The maps and recommended standards should be used by special districts and the state government to guide post-earthquake planning activities.



A = APPROVAL
R&C = REVIEW & COMMENT

Figure 1

Post-Earthquake Land Use Planning Recommended
Governmental Actions and Interactions

High Hazard Areas. After completion of the provisional hazard area maps, the Hazard Evaluation Team should conduct, or call in appropriate experts to conduct more detailed evaluations of the PHA's to determine: 1) potential for damage in future earthquakes, 2) potential means of mitigating the hazard and estimated costs, 3) appropriate building design and construction standards, and 4) more exact boundaries of areas subject to high seismic hazard. In evaluating uses for the PHA's, the HET should consider those uses identified by the Reconstruction Planning Team (RPT) as potentially appropriate. Following the detailed evaluation,the HET should issue maps delineating High Hazard Areas (HHA's) and final recommendations. This should be accomplished within 16 weeks of the disaster declaration. HHA's should include the PHA's or those portions of the PHA's in which there is 1) a high probability for recurrence of ground failure or flooding, and 2) a need for redevelopment or reconstruction to improved building standards to achieve reasonable safety. Results should be fully communicated to the public and to affected public and private agencies. Following review and comment by affected state and local governmental agencies, the Regional Director should approve, with any modifications deemd neessary, the maps and the HET final recommendations. No federal funds should be allocated for permanent repairs or reconstruction in the HHA's until plans for reuse or reconstruction, consistent with the recommendations of the HET, have been adopted by local government. The federal funding agency should be responsible for determining consistency of the locally adopted plan with the HET recommendations.

Reconstruction Planning

Planning for long-term reconstruction after a damaging earthquake is an important responsibility of local governments. However, because of the wide variability in local capabilities, federal and state assistance is often needed in planning and in providing information on federal and state assistance programs. The following sections outline procedures for reconstruction planning and ways to link such planning to the hazard evaluation and, ultimately, the funding of reconstruction projects.

Formation of the Reconstruction Planning Team. Following a Presidential declaration of a major disaster or an earthquake, each affected local government should appoint a Reconstruction Planning Team (PT). The team should be headed by the planning director or the staff member responsible for planning and include staff members from key departments such as public works, building inspection, and engineering. Other professionals, such as experts in land use and redevelopment planning, land appraisal, property acquisition, finance, social planning, housing, and economic development should be called in to work with the team as needed to provide the expertise to address the particular situation. FEMA should fund the work of the RPT and provide technical assistance either by assigning federal personnel to work with the RPT or by funding contracts with private firms to provide the needed expertise.

The purpose of the RPT should be to guide and assist local governments in 1) revising community land use plans which recognize altered conditions brought about as a result of the earthquake, and 2) preparing specific reuse or reconstrution plans for the HHA's designated by the HET, including relocation plans, if needed. The RPT should work closely with the HET in preparing plans for the HHA's.

Revised Community Land Use Plan. The first task of the PRT is to review existing land use and circulation, community plans and regulations, and the location of critical or high-occupancy facilities in relation to the initial damage assessment. The review should be completed within two to three weeks of the disaster declaration. Following issuance of the maps of Provisional Hazard Areas, the RPT should make preliminary revisions in the community land use plan to provide a community-wide perspective and framework for planning for the reconstruction or reuse of the PHA's, identify areas suitable for relocation of major facilities or for the location of temporary housing, identify specific problems related to reconstruction, particularly of critical and high-occupany facilities and lifelines outside the PHA's, and evaluate the land use and circulation relationships between the PHA's and the rest of the community.

The preliminary revisions should be reviewed by the HET, appropriate federal and state agencies, and local legislative bodies and serve as a guide to further planning. Comments from the public and, in particular, property owners in the PHA's should be solicited. Reconstruction projects outside of the PHA's should be reviewed for consistency with the preliminary revisions to the plan. The plan should be considered a working document to be progressively modified and refined as a guide to the reconstruciton effort and specific planning for the PHA's. Following release of the maps of the HHA's and initial planning for the PHA's, the community land use plan should be revised as needed and such revisions adopted by the appropriate local government legislative bodies.

Options for PHA's. On release of maps of the PHA's, the RPT should prepare a preliminary report outlining the options for reuse or reconstruction of each designated PHA. The preliminary community land use plan should serve as a guide in defining the range of possible land use options. The report should be used by the HET in determining the range of land uses which should be evaluated for potential reuse of the PHA's. It should also be used in establishing final boundaries of PHA's designated because of concentrated structural damage. The report should also be used in preparing or revising the community land use plan.

Review and comments on the report should be sought from the FEMA Regional Director, state government, local government, affected special districts, property owners, and the general public.

Specific Plans for HHA's. As maps are released designating HHA's, the RPT should prepare a specific plan for the reconstruction or reuse of each HHA. Each specific plan should include:

1. Map of the High Hazard Area.

2. Recommended land uses, regulations, and building standards for each HHA.

3. Description of any recommended engineering or stabilization measures for each HHA.

4. Location, capacity, and design standards for any public facilities, lifelines, critial or high occupancy structures to be repaired, reconstructed or relocated in a HHA.

5. Identification of properties to be acquired, demolished, or rehabilitated.

6. Owner-participation options and relocation plans as needed.

7. Cost estimates and specification of federal, state, and local share of costs for implementing each plan.

8. A time schedule for implementing each plan.

Each plan should be adopted by the appropriate local legislative bodies and, if federal funding is proposed for implementation, should be consistent with the recommendations of the HET. The federal funding agency should make the determination of consistency. No federal funds for permanent repair of public facilities or non-emergency aid to private property owners in a High Hazard Area should be committed until a plan has been locally adopted and determined by the funding agency to be consistent with the recommendations of the HET. Adoption and determination of consistency should represent a federal commitment to provide the specified share of funds needed for implementation. In redevelopment projects, covenants should be placed in deeds to ensure continuity of the restrictions contained in the plan.

Long-Term Monitoring

Both the HET and RPT should be responsible for recommending procedures to ensure that their recommendations are followed after the teams are offically disbanded. The HET should recommend procedures to ensure that its design and construction standards are complied with, to authorize changes in the boundaries of HHA's based on new information, to arrange for the installation and monitoring of any instruments needed in the HHA's, and to advise local officials concerning other potential hazards in future earthquakes. The RPT should recommend procedures to ensure that plans for reuse or reconstruction of the HHA's are carried out and to authorize changes in the plans consistent with changes in the HET recommendations.

FOOTNOTES

1. The paper draws extensively from a study for which the author was principal investigor, Land Use Planning After Earthquakes (1980). The study was financially supported by National Science Foundation Grant ENV 76-82756 and carried out by William Spangle and Associates, Inc. as principal contractor.

REFERENCES

William Spangle and Associates, Land Use Planning After Earthquakes, George G. Mader, principal investigator, Portola Valley, California: William Spangle and Associates, 1980.