I. Introduction

Over the last decade, the overall cost of disasters to the United States has grown significantly. From 1989 to 1993, the average annual losses from disasters were $3.3 billion. Over the last 4 years, the average annual losses have increased to $13 billion. On the Federal side alone, disasters have cost over $20 billion over the last four years. The disaster losses are equally as staggering for the American public. Since 1993, over 1.4 million Americans have been impacted by Presidentially declared disasters, resulting in the loss of their homes, property, communities, jobs, and in some cases their lives. This figure does not include the hundreds of thousands of people impacted by natural hazard events that were managed entirely at the State and local levels, and involved the personal savings and private resources of property owners. Indeed, the impacts of major disasters on Americans go well beyond those damages that are directly sustained. Recovery from disasters requires resources be diverted from other important public and private programs, and adversely impacts the productivity of economic systems.

To many, the rising costs associated with natural disasters have become unacceptable. To address this growing problem, the Federal Emergency Management Agency (FEMA), under Director James L. Witt, has encouraged the emergency management community to become more proactive in reducing the potential for losses before an event occurs. This proactive strategy is commonly known as "mitigation." Hazard mitigation is defined as *sustained action taken to reduce or eliminate the long-term risk to people and property from hazards and their effects*. This distinguishes mitigation from other major emergency management functions such as preparedness and training, response, and short-term recovery.

This emphasis on mitigation led FEMA to introduce a National Mitigation Strategy in December of 1995 to encourage a national focus on hazard mitigation.[1] The strategy is based on the objective of strengthening the partnership among all levels of government and the private sector and to empower all Americans to fulfill their responsibilities for ensuring safer communities. The strategy was developed with input from State and local officials, as well as individuals and organizations with expertise in hazard mitigation. The strategy has two goals:

- To substantially increase the public awareness of natural hazard risk so that the public demands safer communities in which to live and work; and

[1] Federal Emergency Management Agency, "National Mitigation Strategy: Partnerships for Building Safer Communities" (Washington, DC: Government Printing Office, 1995).

- To significantly reduce the risk of loss of life, injury, economic costs, and destruction of natural and cultural resources that result from natural hazards.

The reason for the emphasis on mitigation is clear. Experience at the Federal, State, and local levels during natural disasters, and a growing body of associated research, has demonstrated that the losses from such events (in terms of life, property, and community resources) can be substantially reduced when mitigation techniques and technologies are applied.

This paper was prepared to illustrate the comparative benefits and costs associated with the implementation of a variety of mitigation measures by Federal, State, and local governments, and private sector entities. To accomplish this, this paper will identify, through a series of case studies, the mitigation tools used to achieve cost-effective hazard mitigation benefits. The case studies used are representative of the types of mitigation measures that are, or could be, performed elsewhere in the nation under similar conditions.

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II. Evaluating Costs and Benefits

Before beginning the case study analyses, it is important to understand the methodologies that were utilized to determine the relative costs and benefits of each mitigation measure. Evaluating natural hazard mitigation is a complex and difficult undertaking which is influenced by several variables. First, natural disasters affect all segments of the communities they strike, including individuals, businesses, and public services such as fire, police, utilities, and schools. Second, while some of the direct and indirect costs of disaster damages are measurable, some of the costs are non-financial and difficult to quantify in dollars. Third, many of the impacts of such events produce "ripple-effects" throughout the community, thus increasing the variables to be considered. While not easily accomplished, there is value, from a public policy perspective, in assessing such impacts and obtaining an instructive cost/benefit comparison. Otherwise, the decision to pursue or not pursue various mitigation options would not be based on an objective understanding of the net benefit or loss associated with these actions.

Because of the inherent difficulties in empirically measuring all the disaster impacts and the corresponding value of mitigation measures, this paper utilized two different methodologies to identify the costs and benefits associated with natural hazard mitigation measures: *benefit/cost analysis* and *cost-effectiveness analysis*. The distinction between the two methods is the way in which the relative costs and benefits are measured. Through the first method, benefit/cost analysis, all costs and benefits are evaluated in terms of dollars and a net benefit/cost ratio is computed to determine whether a project should be undertaken (i.e., if net benefits exceed net costs, the project is worth pursuing). By contrast, the second method, cost-effectiveness analysis, evaluates how best to spend a given amount of money to achieve a specific goal; this type of analysis does not necessarily measure costs and benefits in terms of dollars, or any other common unit of measurement.[2] This paper uses both methods as necessary to obtain a true picture of the value of mitigation in the case studies. Wherever possible however, associated costs and benefits of mitigation measures are measured in terms of dollars.

In completing each case study, many types of cost data were considered in order to define both the direct and indirect costs of natural hazard events. First, the actual cost outlays by Federal, State, and local governments and the private sector are identified in the analysis of each case study. To this end, damages are accounted for to appropriately quantify the costs and benefits of mitigation.[3] In cases where damages could not be taken into account, this paper discusses the reasons why, and any resulting biases. Indirect costs (i.e., costs incurred as a result of the "ripple-effect" of actual damages to other parts of the society or economy) are also identified and discussed, whenever possible. Although it cannot be accurately measured, the reduction of a community's image as a dependable and viable entity, and a reduction in its ability to provide basic services, is recognized as an additional cost.

Throughout the case study analyses, care was taken not to count costs twice in instances where they could be measured in multiple ways. For example, the costs incurred by insurance companies are, in part, a reflection of the value of the damage a building has incurred. The depreciation costs for the usage of capital should also be taken into account in order to account for the actual loss attributable to a natural hazard event. To further clarify, suppose a 10-year old building

[2] Edith Stokey and Richard Zeckhauser, *A Primer for Policy Analysis* (New York: W.W. Norton & Company, 1978), pp. 136-37 and 153.

[3] A set of guidelines for addressing these problems has been developed by Harold C. Cochrane and Charles W. Howe, "Guidelines for the Uniform Definition, Identification, and Measurement of Damages from Natural Hazard Events," *Program on Environment and Behavior, Special Publication No. 29*, Institute of Behavioral Science (Boulder: University of Colorado, 1993).

with a normal life span of 20 years is destroyed; the cost of replacing the building, which is attributable to the disaster, is the capitalized cost of the 10 years of lost usage of the building, not 20.

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III. The Tools of Hazard Mitigation

Mitigation implementation is accomplished using a variety of tools, activities, projects, and programs. Some tools can be utilized only by public sector entities, while some can be used by both the public and the private sector. Mitigation is typically less expensive to implement when included in the planning and construction stage rather than after a building has been constructed. Mitigating the potential for natural hazard damages in existing structures is generally more costly, but when carried out effectively before a disaster, prevents loss of life or reduces damages, and also avoids the outlay of associated costs for response and recovery operations. The following is an illustrative list of some of the most utilized hazard mitigation tools.

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Design and Construction

The design and construction of hazard-resistant structures are perhaps the most cost-effective mitigation measure. The adoption and enforcement of natural hazards building codes, for example, will ensure that structures are resistant to the effects of natural disasters. However, it is important to note that such codes generally apply only to new or substantially improved structures, and this does not guarantee the rehabilitation of most existing hazardous structures.

Where appropriate, the establishment of financial incentives or the adoption of passive or active code triggers (e.g., change of building's use) by State and local governments, the Federal government, and private entities, can reduce existing natural hazard risks. One of the highlighted case studies (the unreinforced masonry regulations in Los Angeles, California) involves the use of local regulatory authority for the adoption of an active trigger to assure that existing hazardous structures are rehabilitated. Another example of a code trigger is to require a building being renovated, after a certain level of disaster damage, to be renovated to a higher level of natural hazards resistance.

The development and application of consensus building codes, and standards of construction for utilities and transportations systems, is a complex process that relies on both the private and public sectors. Building professionals, engineers, land use planners, and others play vital leadership roles in the promulgation and regular updating of building codes and standards. Through grant programs which support a wide range of research and application, technical studies on the usage of building research results in codes and standards, and educational efforts, FEMA and other Federal agencies have played an important role in assuring that such codes and standards are developed and used. State and local governments have a responsibility to adopt building codes that, through local enforcement, assist in creating communities that are built to resist natural hazard damages. And finally, building professionals implement mitigation through compliance with code requirements.

Beyond these building performance tools which are used to assure structural integrity, there are also important mitigation tools for the non-structural elements of buildings, utility systems, and transportation systems. The securing of light fixtures to ceilings, installation of wind shutters, strapping or bolting generators to walls, and numerous other techniques prevent injuries and also allow for the continued operation of businesses and facilities.

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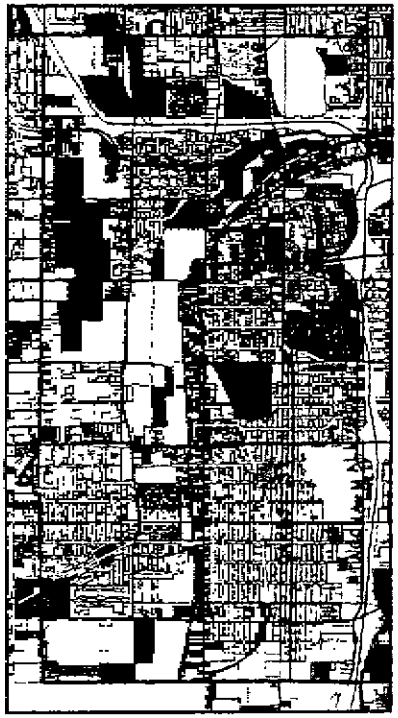

Land Use Planning

The process of establishing and implementing State and community comprehensive development and land use plans provides significant opportunities to mitigate damages caused by natural hazards. Land use planning is generally most effective in areas that have not been developed, or where there has been minimal investment in capital improvements. Since location is a key factor in determining the risks associated with natural hazards, land use plans are a valuable tool in that they can designate low-risk uses for areas that are most vulnerable to natural hazards impacts.

Comprehensive development and land use plans are implemented through ordinances and policies, subdivision, zoning, and sanitary ordinances; police power; and through a jurisdiction's capital improvement program. Tools such as density transfers, transfer of development rights, planned unit developments, cluster development, and similar innovative approaches can ensure that the property owners

receive an adequate return on their investments while still providing community protection against natural hazards. For example, floodplains, steep slopes, areas subject to liquefaction, and areas susceptible to wildfires, can be designated for open space uses while the property owner is allowed to develop the remaining areas of the property at a higher density. This method not only reduces the potential for damages, but open space uses will also enhance the marketability and attractiveness of the development, and may even reduce the developer's costs

A community also can influence the location and density of development through its capital improvement plans which determine where the community places critical infrastructure needed for development, such as roads, water supply, and wastewater treatment. For example, eliminating sewer service extensions onto a barrier island will often result in low density development. Low density development will sustain far less monetary damages than a densely developed area which would likely occur if full infrastructure had been provided. Planning for low density development therefore reduces the opportunity for sustained damages

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Organizational Plans

Organizations need to integrate mitigation into their operating and strategic plans; governments can play a leading role in this integration. An important example of mitigation integration is planning for protection of basic lifelines and the provision of services to preserve public health and safety. State and local governments and private organizations of any size have capital improvements plans for building new facilities and the replacement of inadequate facilities. These plans should include provisions for upgrading replacement facilities using the latest mitigation techniques, and assuring that new facilities are built to the most current codes, standards, and specifications. Corporate and government response plans for natural disasters can also have important mitigation components.

An important concept in mitigation planning is that of redundancies. As an example in the banking industry, every bank over a certain size must have back-up computer facilities at an alternate location, to allow the bank to continue its basic functions should a disaster strike its main facility. Many smaller banks in disaster prone areas already make arrangements to outsource their computer operations to a ser-

vice provider located outside of the bank's area in the event of a disaster. As this example illustrates, an important prerequisite to the success of mitigation is the view that mitigation is a priority with organizations whose constituencies are subject to increased potential for losses due to disasters.

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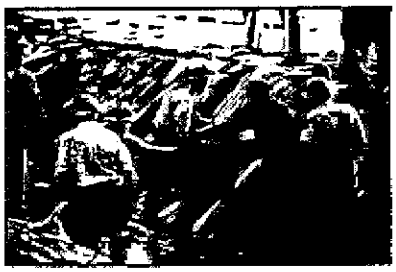
Hazard Control



Mitigation tools that seek to control a hazard, and thus reduce risks and losses are also available. Generally, these tools are used to protect existing at-risk developments and structures. These tools are often not the best to use since they require some maintenance and also tend to constitute a delay of the inevitable forces of nature rather than a permanent solution. Two examples may help to define the category and illustrate the limitations of such tools.

One commonly used and recognized hazard control structure is the levee. The levee has been utilized very effectively to protect flood hazard areas. Yet, the experience of the Midwest Floods of 1993, and other flood events, have clearly demonstrated some of the limitations of these structures—they can be overtopped or breached by floods that exceed their design; they can encourage further at-risk development behind them attributable in part to, an increase in the sense of safety; they can worsen the hazard in other locations; and they can deprive the natural environment of crucial processes, such as wetlands.

The North Carolina Outer Banks, which is a barrier island, also offers a compelling example. The barrier island had sustained major, and in the view of some, fatal, damage to its natural dune structure from a combination of natural and man-made impacts. In the 1930's and early 1940's, the entire barrier island from Cape Hatteras to the Virginia border was successfully rehabilitated with sand dunes and replanted with vegetation. The Outer Banks of post-World War II has seen enormous growth and prosperity as a result of the stabilization of the sand dunes. Some 50 years later however, the dunes are beginning to erode through the natural geologic process, and the beaches, which attract tourists so readily, are diminishing in size. In order to sustain the island's viability, many experts suggest that a landward retreat of the dune and its maintenance will be needed. In the absence of such actions, disaster costs are predicted to grow.

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IV. FEMA Mitigation Programs

FEMA contributed funding towards almost all of the mitigation projects included in the case studies.

FEMA funding for implementing mitigation measures is appropriated for two post-disaster mitigation programs. These are authorized by Sections 404 and 406 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, and provide mitigation assistance after a Presidentially declared Major Disaster Declaration.[4]

Section 404 of the Stafford Act established the Hazard Mitigation Grant Program (HMGP) in 1988. The 1993 Volkmer amendment enhanced the incentive for mitigation implementation by revising the cost sharing requirements, and increased significantly the amount of Federal money available under HMGP. For each Presidentially declared disaster, the amount of HMGP money available is based on 15 percent of the Federal funds spent on the Public and Individual Assistance programs in response to the disaster, minus administrative expenses.

FEMA can fund up to 75 percent of the eligible costs of each mitigation project. State and local governments can request funding for projects to protect either public or private property that meet the minimum HMGP criteria. The HMGP criteria are designed to encourage the most cost-effective and appropriate projects to be selected for funding. Under HMGP, the mitigation projects are not limited to addressing the hazard that caused the disaster declaration; however, the mitigation projects must be part of the overall mitigation strategy for the disaster area. The state sets priorities and allocates funding among applicants that meet state program objectives. The HMGP objectives are to:

- Prevent future losses of lives and property due to disasters;
- Implement State or local Hazard Mitigation Plans,
- Enable mitigation measures to be implemented during immediate recovery from a disaster; and
- Provide funding for previously identified mitigation measures that benefit the disaster area.

Under Section 406 of the Stafford Act, mitigation projects may also be identified and funded, for eligible Public Assistance projects. The Public Assistance Program provides funding for the repair, restoration, or replacement of damaged facilities belonging to governments and to private nonprofit entities, and for other associated expenses, including emergency protective measures and debris removal. Addi-

[4] Major Disaster Declaration is made by the President to supplement the efforts and available resources of States and local governments in alleviating the damage, loss, hardship, or suffering caused by a disaster. The Declaration must be requested by the state.

tionally, the program allows for the funding of mitigation measures related to the repair of the existing damaged facility. The measures must either be required by code or be cost-effective, and comply with program guidance. FEMA will fund at least 75 percent of the eligible costs of the mitigation measure.

Under the National Flood Insurance Program (NFIP) and reform legislation enacted for it in 1994, FEMA is also establishing the processes and regulations to fund flood mitigation implementation. In contrast to the two programs cited above, this flood mitigation assistance (FMA) will be granted before flood disasters transpire. However, by requiring that the flood mitigation implementation benefit the National Flood Insurance Fund, quantifiable flood loss reduction will result The thinking of the Congress in authorizing the flood mitigation assistance is clear—investing in mitigation measures targeted at high-risk areas before disaster strikes, can pay dividends.

While FEMA does have other grant programs that support State and local mitigation activities, these three programs - 404, 406, and FMA - are the principal sources of funds with which FEMA supports the actual implementation of mitigation measures. The projects funded by the two post-disaster programs have provided, and will provide, benefits. The case studies which follow, however, will also demonstrate the indispensable role that pre-disaster mitigation implementation can fulfill.

".. investing in mitigation actions targeted at high-risk areas before disaster strikes, can pay dividends."

As part of FEMA's goals over the next 4 years, one of the major areas of activity will be devoted to establishing a Pre-Disaster Mitigation Fund Program. The program will provide financial incentives for communities in high-risk areas to better protect vulnerable infrastructure and buildings before disasters occur. In FEMA's fiscal year 1997 budget, Congress has allocated $2 million to initiate this effort. However, to make the program viable, the funds available for pre-disaster mitigation projects need to be greatly increased.[5]

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[5] Witt, James L. "Creating the Disaster-resistant Community." *American City & County* January 1997