Parameters for an Independent Study To Assess the Future Benefits of Hazard Mitigation Activities
THE MULTIHAZARD MITIGATION COUNCIL

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Staff: Claret M. Heider, NIBS Vice President for BSSC/MMC Programs; Bernard Murphy, Director, Special Projects; Carita Tanner, Communications/Public Relations Manager; Patricia Blasi, Administrative Assistant

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Parameters for an Independent Study To Assess the Future Benefits of Hazard Mitigation Activities

Prepared for the Federal Emergency Management Agency by the Panel on Assessment of Savings from Mitigation Activities

Multihazard Mitigation Council
National Institute of Building Sciences
Washington, D.C.
July 2002
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This report was prepared under Agreement EMW-1998-CO-0217 between the Federal Emergency Management Agency and the National Institute of Building Sciences. Multihazard Mitigation Council activities and products are described at the end of this report. For further information, contact the Multihazard Mitigation Council, 1090 Vermont, Avenue, N.W., Suite 700, Washington, D.C. 20005; phone 202-289-7800; fax 202-289-1092; e-mail mmc@nibs.org.
Preface

The National Institute of Building Sciences (NIBS), through its Multihazard Mitigation Council (MMC), is pleased to submit to the Federal Emergency Management Agency (FEMA) this report on Phase I, the program definition phase, of an independent study to assess the future savings from hazard mitigation activities.

To conduct the Phase I project, the MMC established a Panel on the Assessment of Savings from Mitigation Activities. The panel includes members from a variety of disciplines with expertise in the effects of natural hazards. The MMC is grateful to the panel members for the time and expertise they contributed to this effort:

Co-chairs
Dennis S. Mileti, Ph.D., Professor and Director, Natural Hazards Center, University of Colorado, Boulder
Brent H. Woodworth, Worldwide Segment Manager, IBM Crisis Response Team, IBM Global Services, Woodland Hills, California

Members
Ken Deutsch, The American Red Cross, Falls Church, Virginia
Philip T. Ganderton, Ph. D., Professor, Department of Economics, University of New Mexico, Albuquerque
David Godschalk, Ph.D., Professor, Department of City and Regional Planning, University of North Carolina, Chapel Hill
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Michael J. O’Rourke, Ph.D., Professor, Department of Civil Engineering, Rensselaer Polytechnic Institute, Troy, New York
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Kathleen Tierney, Ph.D., Professor and Director, Disaster Research Center, University of Delaware, Newark
Carol Taylor West, Ph.D., Professor, Department of Economics, University of Florida, Gainsville

Consultant
L. Thomas Tobin, Tobin and Associates, Mill Valley, California

The panel met four times to determine the study scope, discuss key issues, and review and revise drafts of this report. Representatives of the Congressional Budget Office (Rachel Milberg and Megan Carroll of the Budget Analysis Division and Perry Beider of the Microeconomic and Financial Studies Division) and Government Accounting Office (JayEtta Hecker of the Physical Infrastructure Team and Robert Procaccini and Jack R. Schulze of the Resources, Community, and Economic Development Division) attended one meeting to brief the panel on the approaches their agencies use to assess costs and benefits. In addition, a number of mitigation professionals from the state and local level met with the panel and collaborated in the
preparation of this report. These individuals are Sheela Amin, State Hazard Mitigation Officer, Missouri Emergency Management Agency; Jan Horton, State Hazard Mitigation Officer, Illinois Emergency Management Agency; John Rowden, State Hazard Mitigation Officer, California Office of Emergency Services; Kim Shoaf, Research Director, UCLA Center for Public Health and Disasters; and Gavin Smith, Assistant Director, Mitigation, for North Carolina.

The MMC also is grateful to Margaret Lawless and the many other FEMA mitigation specialists who have contributed to this effort. Special thanks are due to Gerilee Bennett and Robert Sullivan who served as FEMA’s technical advisors to the panel.

Gerald Jones
Chairman, Multihazard Mitigation Council
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Executive Summary

The mandate for the study proposed in this report comes from Report 106–161 for the FY2000 House Appropriations Committee Subcommittee for the Veterans Administration, Department of Housing and Urban Development and Independent Agencies:

The Committee recognizes that investing in mitigation will yield reductions in future disaster losses, and that mitigation should be strongly promoted. However, an analytical assessment is needed to support the degree to which mitigation activities will result in future “savings.” Therefore, the Committee directs FEMA to fund an independent study to assess the future savings resulting from the various types of mitigation activities.

To respond, the Federal Emergency Management Agency (FEMA) charged the Multihazard Mitigation Council (MMC) of the National Institute of Building Sciences (NIBS) with defining the parameters of the needed independent assessment. Under the oversight of the MMC Board of Direction, a panel of volunteer experts from a variety of disciplines was established to carry out this effort with input from a variety of stakeholders.

The panel concluded and the MMC Board agreed that, even though specific hazard events cannot be predicted, valid probability-based models exist to estimate the frequency and intensity of events, likely damage, the ensuing direct and indirect losses, and the savings that can be realized through the implementation of various mitigation measures. With this in mind, the panel formulated an approach for conducting the independent assessment called for by Congress.

The proposed plan for the recommended assessment includes the following:

1. Two interrelated studies on representative mitigation activities and communities to allow nationwide generalizations regarding future savings from mitigation. One study will involve empirical research on the savings realized through the application of specific mitigation activities in varying risk contexts and will utilize a nationwide statistically representative sample of commonly used mitigation activities. The other study will involve empirical research on savings realized through mitigation activities carried out in specific community contexts and will utilize a sample of communities selected purposively in a systematic way that will maximize variations in hazards and mitigation measures considered.

2. Sensitivity analyses to describe the uncertainty inherent in these models and extrapolation techniques.

3. The calculation of future savings for various types and combinations of mitigation activities.

4. The use of existing data kept by FEMA, states, and local jurisdictions; the development of a limited amount of additional data; and the use existing loss estimation models and enhanced benefit/cost methodologies.

5. Consideration of both process1 and project1 mitigation activities for three natural hazards: flood (including flooding associated with riverine and coastal conditions as well

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1 Process mitigation activities lead to policies, practices, and projects that reduce risk. They include efforts to assess hazards, vulnerability, and risk; conduct planning to identify projects, policies, and practices and set priorities; educate decision-makers and build constituencies and political will; and facilitate the selection, design, funding and construction of projects.
as flood surges associated with hurricanes and tsunamis), wind (including winds associated with hurricanes and tornadoes as well as straight-line winds), and earthquake (including the hazards of strong ground shaking, ground failure due to fault rupture, liquefaction and landslides, fire and inundation due to dam or levee failure).

C Quantification of benefits and costs in actual units (e.g., the number of lives saved, acres of habitat reserved as open space, historical structures preserved or other values achieved as a result of the mitigation activities) and their valuation in monetary terms as well as their aggregation in combinations that describe net societal benefits to the Nation and other jurisdictions and units of analysis.

C Use of a study design that is methodologically sound, reliable, transparent, and documented thoroughly so others can apply it. (In other words, proprietary or “black box” methodologies will not be used.)

To conduct the independent assessment, it is proposed that the MMC establish a Project Management Committee (PMC) to guide the overall effort with oversight by the MMC Board of Direction with the assistance of the MMC staff. In addition, a technical Project Manager would be engaged to provide ongoing liaison between the PMC and research/analysis entities engaged to conduct the studies. A Technical Advisory Group comprised of persons interested in the study and representatives of organizations that engage in mitigation also would be established to provide additional perspectives. The multidisciplinary forum provided by the MMC and the experts that the MMC can recruit to participate in the independent study, the proposed committee structure, and open meetings would provide FEMA as well as other interested parties with an opportunity to monitor project activities on a real-time basis.

With respect to the research/analysis entities engaged to conduct the two studies (referred to in this report as Track A and B studies), the intent is to ensure that potential participation in the project is open to private companies, institutes and academic institutions, and consortia of these groups. Although it is possible that one entity might be engaged to perform both the Track A and Track B studies, separate teams of investigators would be needed for each track to ensure that different points of view are considered and to encourage contrasting ideas. Note that both study tracks are considered essential to the overall independent assessment. The research/analysis groups would be selected based on the quality of their proposals, results of interviews, comments of references, and understanding of the project as demonstrated by the proposal. Specific criteria to be used to judge the proposals include technical merit, team qualifications, track record, budget allocation, project management, project coordination, and final product concept.

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1 Project mitigation activities include measures designed to avoid or to reduce damage resulting from disasters including projects to elevate, acquire, and/or relocate buildings, lifelines, and structures threatened by floods; strengthen buildings to resist earthquake or wind forces; and improve drainage and land conditions.
Chapter 1
Introduction

Natural hazards threaten the welfare of all Americans. They place demands on the federal and state treasuries for repair and recovery funds, interrupt commerce and government services, and cause physical and psychological harm to the citizenry. Despite the frequency and cost of disasters, many communities continue to develop in ways that expose them to increasingly larger and more frequent losses.

Although society cannot afford to eliminate risk completely, resilient communities can be developed that are able to withstand hazard events to the extent that residents, businesses, and government can readily recover without the need for external assistance. Mitigation plays an important role in developing such community resilience, and understanding how mitigation reduces future losses, learning which strategies are most effective, and assuring that expenditures are cost-effective are important management concerns. Analytical methods that quantify and describe the benefits of mitigation expenditures will contribute significantly to informed and effective mitigation decisions.

LOSSES DRIVE THE NEED FOR MITIGATION

The exposure to losses from hazard events is increasing as a result of population growth in threatened areas and because economic and infrastructure systems are becoming more valuable, technologically complex, and interdependent.

Compilations of the cost borne by the federal government through FEMA programs and by the insurance industry illustrate the magnitude of disaster losses. Table 1 lists FEMA expenditures during the calendar years from 1988 through June 30, 2001, for public and individual assistance, mission assignments and administration, and mitigation. FEMA spent more than $27.6 billion in over 5,000 counties on disaster recovery and about $2.5 billion on mitigation. Table 2 lists losses paid by the National Flood Insurance Program between 1978 and 2000 and indicates that FEMA paid almost $9.9 billion for flood claims. (See Appendix A for a list of federal disaster assistance programs.)

Private insurance losses also are substantial. Table 3 presents Property Claims Service (PCS) estimates of catastrophic losses between 1988 and 2000 and Institute for Business and Home Safety (IBHS) estimates of paid losses between 1994 and 1999. Table 4 lists insured losses for major natural disasters since 1989; note that these losses do not include losses associated with less costly events that occur more frequently. Insured losses exceed significantly federal disaster payments.

Reducing future losses requires that the private and government sectors invest in mitigation and make development decisions in a manner that balances the risk from hazards with other concerns.
Table 1
FEMA Expenditures for Disaster Assistance and Mitigation Since 1988

<table>
<thead>
<tr>
<th>Calendar Year</th>
<th>Public and Individual Assistance, Mission Assignments and Administration ($)</th>
<th>Hazard Mitigation ($)</th>
<th>FEMA Obligations ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td>2,868,058</td>
<td></td>
<td>2,868,058</td>
</tr>
<tr>
<td>1989</td>
<td>2,218,181,540</td>
<td>100,597,650</td>
<td>2,318,779,190</td>
</tr>
<tr>
<td>1990</td>
<td>406,851,596</td>
<td>22,942,343</td>
<td>429,793,939</td>
</tr>
<tr>
<td>1991</td>
<td>497,821,096</td>
<td>25,463,850</td>
<td>523,284,946</td>
</tr>
<tr>
<td>1992</td>
<td>2,736,162,761</td>
<td>44,263,721</td>
<td>2,780,426,482</td>
</tr>
<tr>
<td>1993</td>
<td>1,649,174,361</td>
<td>196,679,420</td>
<td>1,845,853,781</td>
</tr>
<tr>
<td>1994</td>
<td>7,357,137,872</td>
<td>904,889,719</td>
<td>8,262,027,591</td>
</tr>
<tr>
<td>1995</td>
<td>1,344,445,628</td>
<td>186,171,117</td>
<td>1,530,616,745</td>
</tr>
<tr>
<td>1996</td>
<td>2,136,858,861</td>
<td>284,317,144</td>
<td>2,421,176,005</td>
</tr>
<tr>
<td>1997</td>
<td>1,685,709,402</td>
<td>225,758,855</td>
<td>1,911,468,257</td>
</tr>
<tr>
<td>1998</td>
<td>3,638,029,871</td>
<td>435,629,626</td>
<td>4,073,659,497</td>
</tr>
<tr>
<td>1999</td>
<td>1,764,262,085</td>
<td>181,736,044</td>
<td>1,945,998,129</td>
</tr>
<tr>
<td>2000</td>
<td>1,313,447,227</td>
<td>22,461,556</td>
<td>1,335,908,783</td>
</tr>
<tr>
<td>2001</td>
<td>814,444,245</td>
<td>2,345,400</td>
<td>816,790,645</td>
</tr>
<tr>
<td>Grand Total</td>
<td>27,565,395,603</td>
<td>2,633,256,445</td>
<td>30,198,652,048</td>
</tr>
<tr>
<td>Average</td>
<td>1,968,956,829</td>
<td>188,089,746 *</td>
<td>2,157,046,575</td>
</tr>
</tbody>
</table>

This number is derived by dividing 12-1/2 years of expenditures by 14 years.

Table 2
Losses Paid by the National Flood Insurance Program

<table>
<thead>
<tr>
<th>Fiscal Year Ending September 30</th>
<th>Loss Paid ($ Millions)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978</td>
<td>144.0</td>
</tr>
<tr>
<td>1979</td>
<td>493.0</td>
</tr>
<tr>
<td>1980</td>
<td>219.4</td>
</tr>
<tr>
<td>1981</td>
<td>127.2</td>
</tr>
<tr>
<td>1982</td>
<td>148.6</td>
</tr>
<tr>
<td>1983</td>
<td>484.5</td>
</tr>
<tr>
<td>1984</td>
<td>242.6</td>
</tr>
<tr>
<td>1985</td>
<td>206.2</td>
</tr>
<tr>
<td>1986</td>
<td>280.7</td>
</tr>
<tr>
<td>1987</td>
<td>130.4</td>
</tr>
<tr>
<td>1988</td>
<td>61.2</td>
</tr>
<tr>
<td>1989</td>
<td>608.8</td>
</tr>
<tr>
<td>1990</td>
<td>186.3</td>
</tr>
<tr>
<td>1991</td>
<td>217.3</td>
</tr>
<tr>
<td>1992</td>
<td>527.4</td>
</tr>
<tr>
<td>1993</td>
<td>1,004.5</td>
</tr>
<tr>
<td>1994</td>
<td>170.8</td>
</tr>
<tr>
<td>1995</td>
<td>1,104.4</td>
</tr>
<tr>
<td>1996</td>
<td>1,090.6</td>
</tr>
<tr>
<td>1997</td>
<td>683.5</td>
</tr>
<tr>
<td>1998</td>
<td>689.1</td>
</tr>
<tr>
<td>1999</td>
<td>822.8</td>
</tr>
<tr>
<td>2000</td>
<td>215.8</td>
</tr>
<tr>
<td>Total</td>
<td>9,859.3</td>
</tr>
</tbody>
</table>

### Table 3
Property Claims Service (PCS) Estimates of Catastrophic Losses and Institute for Business and Home Safety’s (IBHS) Estimate of Paid Losses (in $ billions)

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Catastrophes</th>
<th>PCS Estimates Of Insured Losses</th>
<th>IBHS Paid Losses</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td>32</td>
<td>2.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1989</td>
<td>34</td>
<td>10.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>32</td>
<td>3.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1991</td>
<td>36</td>
<td>5.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1992</td>
<td>36</td>
<td>28.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>36</td>
<td>6.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1994</td>
<td>38</td>
<td>19.6</td>
<td>24.8</td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>34</td>
<td>9.4</td>
<td>8.3</td>
<td>Anomaly</td>
</tr>
<tr>
<td>1996</td>
<td>41</td>
<td>8.0</td>
<td>10.8</td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td>25</td>
<td>2.8</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td>1998</td>
<td>37</td>
<td>10.6</td>
<td>9.4</td>
<td>Only 2 years of claims, value should rise</td>
</tr>
<tr>
<td>1999</td>
<td>27</td>
<td>8.6</td>
<td>6.0</td>
<td>Only 1 year of claims, value should rise</td>
</tr>
<tr>
<td>2000</td>
<td>24</td>
<td>4.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>432</td>
<td>$120</td>
<td>$62.2</td>
<td></td>
</tr>
</tbody>
</table>

Note: Insurance Services Office Property Claims Service estimates of insured losses adjusted to 2000 dollars. IBHS Catastrophe Paid Loss database results are derived by scaling claims reported by contributing member companies based on market share to approximate the losses paid by the entire insurance industry. Numbers are adjusted to 2000 dollars.

### Table 4
Insured Losses for Major Natural Disasters Since 1989

<table>
<thead>
<tr>
<th>Disaster</th>
<th>Dates</th>
<th>Insured Losses ($ billions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hurricane Andrew</td>
<td>August 1992</td>
<td>15.5</td>
</tr>
<tr>
<td>Northridge Earthquake</td>
<td>January 1994</td>
<td>12.5</td>
</tr>
<tr>
<td>Hurricane Hugo</td>
<td>September 1989</td>
<td>4.2</td>
</tr>
<tr>
<td>Hurricane Opal</td>
<td>October 1995</td>
<td>2.1</td>
</tr>
<tr>
<td>Hurricane Floyd</td>
<td>September 1999</td>
<td>1.8</td>
</tr>
<tr>
<td>Severe Winter Storms</td>
<td>March 1993</td>
<td>1.7</td>
</tr>
<tr>
<td>Firestorm in Oakland/Berkeley</td>
<td>October 1991</td>
<td>1.7</td>
</tr>
<tr>
<td>Severe Winter Storms</td>
<td>January and February 1994</td>
<td>1.6</td>
</tr>
<tr>
<td>Hurricane Iniki</td>
<td>September 1992</td>
<td>1.6</td>
</tr>
<tr>
<td>Hailstorms in Texas and New Mexico</td>
<td>May 1995</td>
<td>1.135</td>
</tr>
<tr>
<td>Loma Prieta Earthquake</td>
<td>October 1989</td>
<td>0.96</td>
</tr>
<tr>
<td>Fires in Southern California</td>
<td>October and November 1993</td>
<td>0.725</td>
</tr>
<tr>
<td>Wind, Hail and Tornados in Denver</td>
<td>July 1990</td>
<td>0.625</td>
</tr>
<tr>
<td>Midwest Floods</td>
<td>June to August 1993</td>
<td>0.6</td>
</tr>
<tr>
<td>Total</td>
<td><strong>September 1989 to October 1995</strong></td>
<td><strong>$46.745</strong></td>
</tr>
</tbody>
</table>
### Disaster Mitigation

<table>
<thead>
<tr>
<th>Disaster</th>
<th>Dates</th>
<th>Insured Losses ($ billions)</th>
</tr>
</thead>
</table>


### CONGRESSIONAL CHARGE

The mandate for the study proposed in this report comes from Report 106–161 for the FY2000 House Appropriations Committee Subcommittee for the Veterans Administration, Department of Housing and Urban Development and Independent Agencies:

- The Committee recognizes that investing in mitigation will yield reductions in future disaster losses, and that mitigation should be strongly promoted. However, an analytical assessment is needed to support the degree to which mitigation activities will result in future “savings.”
- Therefore, the Committee directs FEMA to fund an independent study to assess the future savings resulting from the various types of mitigation activities.

The Disaster Mitigation Act of 2000 (PL 106–390, October 30, 2000) amended the Robert T. Stafford Disaster Relief and Emergency Assistance Act (42 USC 5121) and provided for a similar study (Section 209, Study Regarding Cost Reduction):

- Not later than 3 years after the date of the enactment of this Act, the Director of the Congressional Budget Office shall complete a study estimating the reduction in Federal disaster assistance that has resulted and is likely to result from the enactment of this Act.

### PURPOSE AND CONTENT OF THIS REPORT

This report recommends an approach to conduct of the independent study to assess the future savings to be realized from the various types of mitigation activities that is consistent with economic principles and practices for determining cost effectiveness of government programs. Chapters 2 and 3 describe mitigation activities, their sources of funding, and the methods for determining benefits and costs of such activities. The approach to the independent study is described in Chapter 5. Appendices present general information as well as background papers on specific topics developed by the panel members for use during panel deliberations. References and a bibliography conclude the report.
Chapter 2
Mitigation: Types of Activities and Sources of Funding

The Congressional charge for an independent study of future savings from mitigation activities refers to “various types of mitigation activities.” However, because mitigation activities include all actions taken to reduce or eliminate long-term risk to people and property from hazards and their effects, the number of possible activities is very large. Table 5 categorizes mitigation activities and identifies specific types of project included in each category. Mitigation activities contrast with short-term risk-reducing actions such as preparedness, response, recovery, and risk-spreading measures such as insurance.

Table 5
Various Types of Mitigation Activities

<table>
<thead>
<tr>
<th>Type</th>
<th>Types of Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>I Education/Training</td>
<td>Offering workshops and seminars for public officials and employees, personnel of state agencies, and the general public</td>
</tr>
<tr>
<td></td>
<td>Developing video tapes, pamphlets, brochures, and other literature</td>
</tr>
<tr>
<td>II Commitment and Capacity Building</td>
<td>Organizing community groups and conducting team-building exercises</td>
</tr>
<tr>
<td></td>
<td>Recruiting partners to promote mitigation</td>
</tr>
<tr>
<td></td>
<td>Forming teams or committees for planning and conducting preparedness, response, and recovery planning</td>
</tr>
<tr>
<td></td>
<td>Encouraging interagency cooperation and planning</td>
</tr>
<tr>
<td>III Risk Assessment, Planning, and Plan Implementation</td>
<td>Conducting hazard, vulnerability, and risk analyses; mapping hazards; preparing inventories of threatened facilities; and carrying out other studies</td>
</tr>
<tr>
<td></td>
<td>Preparing plans (e.g., risk mitigation plans, land improvements plans, harbor management plans, and beach management plans)</td>
</tr>
<tr>
<td></td>
<td>Supporting planning, administrative, and legislative activities</td>
</tr>
<tr>
<td></td>
<td>Forming planning and hazard management districts</td>
</tr>
<tr>
<td></td>
<td>Developing and/or strengthening zoning and building code ordinances</td>
</tr>
<tr>
<td></td>
<td>Enacting new risk mitigation regulations and legislation</td>
</tr>
<tr>
<td></td>
<td>Conducting engineering studies and designing projects</td>
</tr>
<tr>
<td></td>
<td>Developing mitigation incentives such as loan subsidy and/or grant programs</td>
</tr>
<tr>
<td></td>
<td>Providing technical assistance</td>
</tr>
<tr>
<td></td>
<td>Implementing risk mitigation plan</td>
</tr>
<tr>
<td></td>
<td>Coordinating risk mitigation activities</td>
</tr>
<tr>
<td>IV Drainage Projects</td>
<td>Replacing and improving culverts, pipes, mains, storm water lines, drainage ditches, channels, sewer pipes, and backup valves</td>
</tr>
<tr>
<td>Type</td>
<td>Types of Activity</td>
</tr>
<tr>
<td>------</td>
<td>------------------</td>
</tr>
<tr>
<td></td>
<td>Constructing and stabilizing detention ponds and basins, dams, dikes, levees, barriers, berms, floodgates, and flood walls</td>
</tr>
<tr>
<td></td>
<td>Stabilizing riverbanks and shorelines (retaining walls, riprap)</td>
</tr>
<tr>
<td></td>
<td>Dredging and maintaining channels</td>
</tr>
<tr>
<td></td>
<td>Removing debris and vegetation</td>
</tr>
<tr>
<td>V</td>
<td>Acquisition and Relocation Projects</td>
</tr>
<tr>
<td></td>
<td>Acquiring, demolishing, and/or relocating structures in flood zones</td>
</tr>
<tr>
<td></td>
<td>Purchasing land and development rights in flood and erosion zones</td>
</tr>
<tr>
<td>VI</td>
<td>Structural Improvement Projects</td>
</tr>
<tr>
<td></td>
<td>Improving and retrofitting buildings and structures to resist earthquakes, wind, hail, water, and waves</td>
</tr>
<tr>
<td></td>
<td>Floodproofing buildings and infrastructure in flood zones</td>
</tr>
<tr>
<td></td>
<td>Elevating buildings and other structures</td>
</tr>
<tr>
<td></td>
<td>Installing storm shutters and upgrading roofs to resist wind, rain, hail, and fire</td>
</tr>
<tr>
<td></td>
<td>Constructing hurricane walls, barriers, gates, and tidal valves</td>
</tr>
<tr>
<td></td>
<td>Constructing seawalls, breakwaters, jetties, and riprap</td>
</tr>
<tr>
<td></td>
<td>Constructing new buildings, lifelines, and other structures to meet appropriate codes</td>
</tr>
<tr>
<td></td>
<td>Repairing damaged buildings in ways to reduce repeated losses</td>
</tr>
<tr>
<td></td>
<td>Constructing and upgrading emergency shelters</td>
</tr>
<tr>
<td></td>
<td>Installing roll-up doors, special windows, and impact-resisting film</td>
</tr>
<tr>
<td>VII</td>
<td>Lifeline Improvement Projects</td>
</tr>
<tr>
<td></td>
<td>Upgrading piers and wharves</td>
</tr>
<tr>
<td></td>
<td>Upgrading fuel storage tanks</td>
</tr>
<tr>
<td></td>
<td>Anchoring and bracing equipment</td>
</tr>
<tr>
<td></td>
<td>Improving utilities such as storm water, wastewater, and water treatment facilities and pumping stations; and electric, gas, communications systems</td>
</tr>
<tr>
<td></td>
<td>Improving transportation systems (roads, bridges, etc.)</td>
</tr>
<tr>
<td>VIII</td>
<td>Land Improvement Projects</td>
</tr>
<tr>
<td></td>
<td>Replenishing beaches</td>
</tr>
<tr>
<td></td>
<td>Stabilizing and restoring sand dunes and roadway banks</td>
</tr>
<tr>
<td></td>
<td>Constructing and/or strengthening bulkheads and head walls</td>
</tr>
<tr>
<td></td>
<td>Managing vegetation</td>
</tr>
<tr>
<td></td>
<td>Controlling erosion (grading and vegetation)</td>
</tr>
<tr>
<td></td>
<td>Stabilizing slopes (grading, drainage and vegetation)</td>
</tr>
<tr>
<td></td>
<td>Remediating soil to reduce liquefaction potential</td>
</tr>
<tr>
<td></td>
<td>Clearing brush, doing controlled burns, and building fuel breaks</td>
</tr>
</tbody>
</table>

Source: Derived from Godschalk et al., 1999.
PROCESS AND PROJECT MITIGATION ACTIVITIES

Basically, mitigation activities are categorized for the purposes of this report as process and project activities.

Process – or indirect – mitigation activities lead to policies, practices, and projects that reduce risk. They include efforts to:

- Assess hazards, vulnerability, and risk;
- Conduct planning to identify projects, policies, and practices and set priorities;
- Educate decision-makers and build constituencies and political will; and
- Facilitate the selection, design, funding, and construction of projects.

These activities stimulate the commitments needed to sustain mitigation efforts over the long term. The outcomes from some process activities are difficult to predict, particularly in the short term. Although some process activities will not be successful, when they do succeed, they lead to large-scale adoption of mitigation measures and the resulting savings will greatly exceed their relatively small cost. In fact, process activities ultimately may reduce risk to a much greater extent for each dollar invested than individual projects because they encourage others to invest in mitigation and, therefore, may be much more effective in developing community resilience. For example, building code adoption and enforcement can affect thousands of projects over time with benefits accruing as each project is completed and lasting as long as each structure remains. Categories I through III in Table 5 include typical process activities.

Project mitigation activities include measures to avoid or reduce damage resulting from hazard events. They include projects to:

- Elevate, acquire, and/or relocate buildings, lifelines, and other structures threatened by floods;
- Strengthen buildings and lifelines to resist earthquake or wind forces; and
- Improve drainage and land conditions.

Project mitigation activities directly reduce risk, take a finite time to complete, and have identifiable outcomes. Categories IV through VIII in Table 5 include typical project activities.

Table 6 gives the number of projects and funds obligated by FEMA between 1990 and May 2001, and the panel recommends that the independent study proposed in this report focus on the most common of these project and process mitigation activities.

<table>
<thead>
<tr>
<th>Process/Project</th>
<th>Category</th>
<th>Number of Projects</th>
<th>Federal Share Obligated ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process</td>
<td>Codes, standards, ordinances and regulations</td>
<td>58</td>
<td>28,274,936</td>
</tr>
<tr>
<td></td>
<td>Mitigation plans and studies</td>
<td>216</td>
<td>32,287,614</td>
</tr>
<tr>
<td></td>
<td>Other non-construction</td>
<td>64</td>
<td>10,533,521</td>
</tr>
<tr>
<td></td>
<td>Professional education and public awareness</td>
<td>160</td>
<td>24,949,689</td>
</tr>
<tr>
<td></td>
<td>Subtotal</td>
<td>498</td>
<td>96,045,760</td>
</tr>
<tr>
<td>Project</td>
<td>Acquisition and relocation of real property</td>
<td>1,229</td>
<td>752,871,354</td>
</tr>
<tr>
<td>Process/Project</td>
<td>Category</td>
<td>Number of Projects</td>
<td>Federal Share Obligated ($)</td>
</tr>
<tr>
<td>-----------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>--------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>Elevation and floodproofing</td>
<td></td>
<td>204</td>
<td>72,616,502</td>
</tr>
<tr>
<td>Equipment (generators, communications, etc.)</td>
<td></td>
<td>275</td>
<td>24,074,640</td>
</tr>
<tr>
<td>Infrastructure protective measures (roads and bridges)</td>
<td></td>
<td>160</td>
<td>27,363,513</td>
</tr>
<tr>
<td>Major, minor and localized flood control</td>
<td></td>
<td>915</td>
<td>419,769,843</td>
</tr>
<tr>
<td>Retrofitting (seismic)</td>
<td></td>
<td>419</td>
<td>703,968,296</td>
</tr>
<tr>
<td>Retrofitting (safe rooms for wind wildfire)</td>
<td></td>
<td>426</td>
<td>112,815,296</td>
</tr>
<tr>
<td>Stabilization (shoreline and landslide)</td>
<td></td>
<td>101</td>
<td>14,103,280</td>
</tr>
<tr>
<td>Utility protective measures</td>
<td></td>
<td>184</td>
<td>73,177,573</td>
</tr>
<tr>
<td>Vegetation management</td>
<td></td>
<td>117</td>
<td>16,193,945</td>
</tr>
<tr>
<td>Water and sanitary sewer system protective measures</td>
<td></td>
<td>195</td>
<td>41,226,650</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td></td>
<td><strong>4,225</strong></td>
<td><strong>2,258,180,892</strong></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>State Management Costs</td>
<td></td>
<td>360</td>
<td>37,960,844</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td></td>
<td>117</td>
<td>43,907,087</td>
</tr>
<tr>
<td>Warning Systems</td>
<td></td>
<td>329</td>
<td>50,570,056</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td></td>
<td><strong>806</strong></td>
<td><strong>$132,437,987</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>5,529</strong></td>
<td><strong>$2,486,664,639</strong></td>
</tr>
</tbody>
</table>


**SOURCES OF MITIGATION FUNDING**
Sources of mitigation funding and the objectives expressed by the authorizing legislation affect the nature of mitigation activities. Sections 404 and 406 of the *Stafford Act*, the Pre-Disaster Mitigation fund established by the *Disaster Mitigation Act of 2000*, and Federal Mitigation Assistance associated with the National Flood Insurance Program authorize federal matching funds. These sources are described below; additional sources of federal funding are identified in Appendix A.

**The Stafford Act**
Section 404 mitigation activities are appropriated in amounts proportional to the cost of response and repair efforts authorized by the *Stafford Act*. It is the largest source of funds for mitigation activities, and the one with the greatest potential to reduce future disaster losses. Section 404 provides that 15 percent, and in some cases 20 percent, of the funds spent for Public Assistance and Individual and Family Grants may be spent for a wide variety of mitigation activities. Since early 1989, FEMA has paid out $2.63 billion under this program (about $211 million per year). Funds are granted to the state as the “grantee” and are spent by qualified “sub grantees” on eligible projects located within the state. Priorities are set by the state and projects can be used to mitigate against losses from any hazard. Projects must be cost-effective and a nonfederal match of at least 25 percent is required.
Section 406 allows for a more narrow selection of mitigation activities – physical projects on
damaged facilities – than FEMA’s other programs. Hazard mitigation is defined as cost-effective
action taken to prevent or reduce the threat of future damage to a facility. A maximum nonfederal
match of 25 percent or less is required. Mitigation funded by Section 406 only applies to buildings
and infrastructure damaged by a Presidentially declared disaster and is above and beyond the
work required to return the damaged facility to its pre-disaster design. Section 406 mitigation is
addressed by 44CFR 206.226 (see Appendix B) and by Response and Recovery Policy 9526.1
(FEMA 1998b). Section 7(c) of the FEMA policy provides that:

i. Mitigation measures must be determined to be cost-effective. Any one of the following means may be
   used to determine cost-effectiveness:
   i. Measures may amount to up to 15 percent of the total eligible cost of the eligible repair work
      on a particular project.
   ii. Certain mitigation measures (see Appendix A) will be determined to be cost-effective, as
       long as the mitigation measure does not exceed the eligible cost of the eligible repair work
       on the project.
   ii. For measures that exceed the above costs, the Grantee or Subgrantee must demonstrate
       through an acceptable benefit/cost analysis that the measure is cost-effective.

Appendix A of the policy defines mitigation measures as being cost-effective if they:

C Do not exceed 100 percent of the project cost
C Are appropriate to the disaster damage
C Will prevent future similar damage
C Are directly related to the eligible damaged elements
C Do not increase risks or cause adverse effects to the property or elsewhere
C Meet standards of good professional judgment

A recent internal review, Hazard Mitigation in the Public Assistance Program (FEMA 2001b)
evaluated expenditures associated with Section 406 mitigation for projects resulting from 57
disasters approved between October 1, 1998, and May 30, 2000. The review found that the cost
of mitigation was $50.8 million or 9 percent of the repair cost.

The Disaster Mitigation Act of 2000
The Disaster Mitigation Act of 2000 authorizes spending $25 million per year and encourages a
broad accounting of benefits. Section 101(b)(2) the Act states that the intent is:

. . . to provide a source of predisaster hazard mitigation funding that will assist States and local
governments (including Indian tribes) in implementing effective hazard mitigation measures that are
designed to ensure the continued functionality of critical services after a natural disaster.

The Flood Insurance Program
The National Flood Insurance Program provides Flood Mitigation Assistance (FMA) grant funds to
state and local governments for studies, research, and mitigation for structures covered by flood
insurance. The funds come from flood insurance premiums, and the appropriation is $20 million
per year.

MITIGATION CONTEXT
Mitigation project and process activities occur within a context unique to a locality. Communities
have the power to influence the location, density, quality, and timing of development and
redevelopment. Significant savings come when communities make long-term commitments to
mitigation activities and set priorities appropriate to local conditions. Limiting the impacts of natural disasters on Americans and reducing the need for federal disaster recovery expenditures ultimately reflect independent actions by public and private interests acting at the state and community levels.

Supportive community leaders are crucial in exercising the power and influence needed to avoid the risks posed by hazards when making policy decisions. Thus, activities that motivate community leaders to integrate risk management objectives with other community policies, plans, and programs will lead to successful mitigation. Local motivation also requires recognition of the risks from natural hazards and acceptance of responsibility for making decisions to reduce those risks.

Because of variations in hazard potential and vulnerability and the differences between communities, no single or fixed combination of mitigation activities will be successful everywhere, every time. Communities need alternative solutions from which to choose. Allowing local flexibility – the ability to decide what to do and when to do it – is critical for gaining the community support. Thus, assessing the savings from an integrated set of activities may be a better measure of future savings than simply maximizing the ratio of benefits to costs on a project-by-project basis. Getting the most savings from federal mitigation investments is an important objective, but there is a need for caution when trying to select activities based solely on projected savings calculated only in monetary terms. Strategies that combine efforts to build community commitment and capacity with selected individual projects are likely to result in greater savings with less federal investment than strategies based solely on federal funding of cost-effective physical projects. Over-reliance on economic comparisons, such as the ratio of benefits to costs and maximum net benefits, in selecting individual projects or setting priorities may overemphasize the long-term value of specific projects at the expense of process activities.
Chapter 3
Defining the Benefits and Costs

Disasters affect American society in numerous negative ways. Besides the pain of injuries and disrupted lives, disasters destroy wealth and transfer income from victims to others. Community character as well as family farm and small business ownership can be lost. Disaster aid, whether from the federal or state government or private insurance, facilitates recovery but seldom makes victims “whole.” Disaster payments also remove funds from other socially or economically important investments whereas mitigation reduces losses and facilitates the use of capital for socially beneficial purposes. Thus, the savings or benefits resulting from mitigation activities consist of both reduced losses that can be valued in monetary terms and other reduced losses that are not readily measured in monetary terms.

QUANTIFYING BENEFITS AND COSTS
There exists a robust and growing body of literature regarding natural hazards, mitigation, loss estimation, and economic analysis that support measurement of benefits and costs. The results of literature searches undertaken at the University of Delaware’s Disaster Research Center and the University of Colorado’s Natural Hazards Research and Applications Information Center are included in the References and Bibliography section that concludes this report. The searches included review of the collections housed at the two centers, online databases, and the database at the Multidisciplinary Center for Engineering Research (MCEER). A more thorough literature review would be an appropriate beginning to the independent study.

Methods exist to estimate disaster losses and savings (i.e., losses avoided) from project mitigation activities with a reasonable degree of certainty given sufficient knowledge about:

- The hazards (recurrence intervals, intensity of events, and comparisons among hazards),
- Community vulnerability (amount of damage and disruption relative to the extent and intensity of the event),
- Exposure (location, number and type of buildings and infrastructure in areas exposed to the hazard presently and in the future), and
- Changes in causation agents (tectonic movements and development in watersheds and floodplains).

Estimating the savings from process mitigation activities is complicated because the results of these activities are difficult to quantify. Future savings from process mitigation activities are achieved when local and state leaders and building and infrastructure owners incorporate mitigation concepts into day-to-day decisions. Activities that raise hazard awareness and inspire land use planning, code enforcement, and community-wide participation are essential ingredients to reducing disaster losses. Policies and practices are eventually realized through physical projects, avoided hazardous areas, and appropriate new development. A new methodology is needed to link process outputs with loss-saving outcomes.

Well developed techniques can quantify and compare benefits and costs. These methods compare monetized and non-monetized future benefits and costs discounted to present value. Loss estimation techniques can be used that estimate benefits – the net change in future losses – by combining the probability of hazardous events occurring each year with the susceptibility of communities to damage and exposure on a geographical basis. Losses represent negative
economic impacts and consist of direct and indirect losses that can be valued. Direct losses\(^1\) are due to damage and indirect losses\(^2\) emanate from disruption to physical and social systems. In other words, indirect losses represent the consequences of damage and include all losses other than direct losses. Economic gains from recovery expenditures will offset some losses. Thus, the independent study should estimate direct and indirect losses using market and non market valuation methods.

**NEED FOR A BROAD DEFINITION OF SAVINGS**

Future savings from or the benefits of mitigation activities are reduced losses of all types – human, financial, cultural, and environmental and are enjoyed by a variety of stakeholders – federal, state and local government agencies, businesses, and the public. Mitigation will reduce demand for emergency response and recovery assistance and advance other federal objectives, such as providing affordable housing, maintaining tax revenues, enhancing commerce, and protecting historic resources. States and communities and their residents also benefit from mitigation in many ways because mitigation activities often address several objectives simultaneously. For example, a measure to restrict development in a floodplain also may limit development in an area subject to ground failure during an earthquake, protect environmentally valuable habitat, provide open space and maintain flood storage capacity. Multiple benefits that contribute to the welfare of all Americans are important outcomes of mitigation activities. Capturing the full range of benefits requires an assessment that defines societal benefits broadly; however, care must be taken to avoid double counting and to ensure that transfers (i.e., gains and losses) are appropriately accounted for given various geographic areas of analysis.

The independent study therefore should reflect a broad definition of savings. OMB Circular No. A-94 (Sections 6 and 6a) indicates that:

Analyses should include comprehensive estimates of the expected benefits and costs to society based on established definitions and practices for program and policy evaluation. Social net benefits, and not the benefits and costs to the Federal Government, should be the basis for evaluating government programs or policies that have effects on private citizens or other levels of government. Social benefits and costs can differ from private benefits and costs as measured in the marketplace because of imperfections arising from…external diseconomies . . . monopoly power . . . and taxes or subsidies.

Both intangible and tangible benefits and costs should be recognized.

---

\(^1\) Losses linked directly to a hazard event include all damages, deaths and injuries, loss of habitation, shelter demand and employment losses due to the closure of damaged facilities. This includes physical destruction of buildings, transportation and utility systems, crops, and natural resources and employment losses due directly to the closure of damaged facilities.

\(^2\) All losses other than direct losses include economic losses due to dislocations in undamaged factories or commercial ventures, banking and insurance, temporary unemployment and business interruption, losses due to economic “ripple effects,” environmental consequences, nonfinancial losses such as loss of historical resources, and psycho-social effects suffered by persons involved in a disaster. Net losses reflect the fact that gross losses are offset to an extent by the positive economic effects of a disaster and recovery investments.
Support for a broad definition also is found in Section 101(b) of the Disaster Mitigation Act of 2000 amendments to the Stafford Act:

. . . is to establish a national disaster hazard mitigation program –

(1) to reduce the loss of life and property, human suffering, economic disruption, and disaster assistance costs resulting from natural disasters; and

(2) to provide a source of predisaster hazard mitigation funding that will assist States and local governments (including Indian tribes) in implementing effective hazard mitigation measures that are designed to ensure the continued functionality of critical services after a natural disaster.

Section 203(b) indicates that:

. . . The President may establish a program to provide technical and financial assistance to States and local governments to assist in the implementation of predisaster hazard mitigation measures that are cost-effective and are designed to reduce injuries, loss of life, and damage and destruction of property, including damage to critical services and facilities under the jurisdiction of the States or local governments.

Section 404, of the Stafford Act, the section dealing with mitigation, states that:

. . . The President may contribute up to 75 percent of the cost of hazard mitigation measures which the President has determined are cost-effective and which substantially reduce the risk of future damage, hardship, loss or suffering in any area affected by a major disaster….

The objectives of the Stafford Act (to reduce the loss of life and property, human suffering, economic disruption and disaster assistance costs and to ensure continued functionality of critical services after disasters) support a broad definition of benefits and costs that accrue to the community, state, and nation. Thus, the MMC Panel believes that the independent study should consider all negative human, economic, and environmental impacts and all direct and indirect benefits and costs (including market and nonmarket values).
Chapter 4
Recommended Approach to the Independent Assessment

INTRODUCTION

The MMC Panel believes that it is feasible to assess the future savings resulting from mitigation activities. Even though specific hazard events cannot be predicted, valid probability-based models exist to estimate the frequency and intensity of events, likely damage, the ensuing direct and indirect losses, and the savings that can be realized through the implementation of various mitigation measures.

The project to conduct the independent assessment of future savings proposed in this report is designed to answer the question that was posed in the FEMA Appropriations Bill for 2000: “What are the future savings that result from the various types of natural hazards mitigation?” The approach recommended is to carry out two related studies on representative mitigation activities and communities to allow nationwide generalizations regarding future savings from mitigation. Sensitivity analyses will be used to describe the uncertainty inherent in modeling and extrapolation techniques, and future savings for various types and combinations of mitigation activities will be calculated. Existing loss estimation models and enhanced benefit/cost methodologies will be employed. Existing data collected by FEMA and state and local jurisdictions will be used to the greatest extent possible; however, some new data will need to be assembled.

The studies will consider both process\(^1\) and project\(^2\) mitigation activities. Benefits and costs will be quantified in actual units (e.g., the number of lives saved, acres of habitat reserved as open space, historical structures preserved or other values achieved as a result of the mitigation activities), valued in monetary terms, and aggregated in combinations that describe net societal benefits to the nation as well as to specific jurisdictions and units of analysis. The design and approach for the studies will be methodologically sound, reliable, transparent, and documented thoroughly so others can apply it; in other words, proprietary or “black box” methodologies will not be used.

The two discrete studies – referred to here as Track A and Track B – will be carried out simultaneously over a two-year period. The intent is that those who conduct the studies share data, use common methodological approaches, and integrate study results. Each study track

\(^1\) Process – or indirect – mitigation activities lead to policies, practices, and projects that reduce risk. They include efforts to assess hazards, vulnerability, and risk; conduct planning to identify projects, policies, and practices and set priorities; educate decision-makers and build constituencies and political will; and facilitate the selection, design, funding, and construction of projects.

\(^2\) Project mitigation activities include measures to avoid or to reduce damage resulting from hazard events. They include projects to elevate, acquire, and/or relocate buildings, lifelines, and structures threatened by floods; strengthen buildings to resist earthquake or wind forces, and improve drainage and land conditions.
will be documented in a technical report including detailed descriptions of the methodology and data used as well as the results of sensitivity analysis. In addition, a summary report will be prepared to present the overall results and document the effort.

The Track A and B studies will focus on FEMA-funded mitigation activities for flood (including flooding associated with riverine and coastal conditions as well as flood surges associated with hurricanes and tsunamis), wind (including winds associated with hurricanes and tornadoes as well as straight-line winds), and earthquake (including the hazards of strong ground motion, ground failure due to fault rupture, liquefaction and landslides, fire and inundation due to dam or levee failure). If funding is sufficient, mitigation activities for severe weather and wildland-urban interface fires also should be included in the assessment.

STUDY DESIGN

The Track A and Track B studies closely parallel one another in many respects; therefore, the work plan below includes tasks that are common to both tracks (Tasks 1, 2, 4, and 5) as well as tasks (Task 3) specific to each track.

The Track A study involves empirical research on the savings realized through the application of specific mitigation activities in varying risk contexts. For this track, analyses should be conducted on a nationwide, statistically representative sample of commonly used mitigation activities.

The Track B study involves empirical research on the savings realized through mitigation activities carried out in specific community contexts. For this track, a sample of communities should be selected purposively in a systematic way so as to maximize variations in the hazards and mitigation measures considered. This track will model outcomes and outputs that occur as the consequence of both process and project mitigation activities implemented at the community level. It will employ in-depth methods to measure costs and benefits and will focus on a broad definition of costs and benefits, including secondary and ancillary costs and benefits and synergistic effects. The study design and sampling approach should permit conclusions to be drawn that theoretically can be generalized nationwide and that will add additional insights on results obtained from the Track A study.

STUDY CONDUCT AND MANAGEMENT

To conduct the independent assessment, it is proposed that the NIBS Multihazard Mitigation Council establish a Project Management Committee (PMC) to manage the overall effort with oversight by the MMC Board of Direction with the assistance of the MMC staff. In addition, a technical Project Manager will be engaged to provide ongoing liaison between the PMC and the research/analysis entities engaged to conduct the Track A and Track B studies. A Technical Advisory Group comprised of persons interested in the study and representatives of organizations that engage in mitigation also will be established to provide additional perspectives. The multidisciplinary forum provided by the MMC and the experts that the MMC can recruit to participate in the independent study, the proposed committee structure, and open meetings will provide FEMA as well as other interested parties such as the GAO and CBO with an opportunity to monitor project activities on a real-time basis.

With respect to the research/analysis entities engaged to conduct the Track A and B studies, the intent is to ensure that potential participation in the project is open to private companies,
institutes and academic institutions, and consortia of these groups. Although it is possible that one entity might be engaged to perform both the Track A and Track B studies, separate teams of investigators would be needed for each track to ensure that different points of view are considered and to encourage contrasting ideas. Note that both study tracks are considered essential to the overall independent assessment.

Multihazard Mitigation Council Board of Direction

As noted above, the MMC Board of Direction will serve as the project oversight body and provide the research entities and the PMC with the opportunity to hear from the disciplines and stakeholder representatives needed for the successful completion of the study. MMC Board members will not be compensated for their time but will be reimbursed for travel expenses. Specifically the MMC Board will:

1. Ensure appropriate balance of project groups and facilitate participation by and input from all relevant sectors and disciplines;

2. Meet semiannually to consider study implementation issues;

3. Review the methodology, availability of data, and usability and validity of results;

4. Participate in the crucial project meetings; and

5. Review drafts of interim and final report(s) and provide comments to the PMC.

Project Management Committee

The five-person Project Management Committee will be composed of recognized experts familiar with hazard mitigation work and possessing needed expertise in the social sciences, economics, and loss modeling. The purpose of the committee is to ensure the technical merit of the research/analysis work and the validity of the conclusions reached. Members of the PMC will be reimbursed for expenses and provided an honorarium. Committee members cannot have any financial association with contractors. The PMC will perform the following tasks:

1. Review and approve potential research entity proposals;

2. Evaluate proposals and recommend contractor selection to the MMC Board;

3. Approve the detailed work plan, study approach, and data collection/documentation formats;

4. Recommend changes to the project methodology to assure its continuing validity and to respond to changed conditions;

5. Approve project work plan, methodology, or scope changes;
6. Meet quarterly to discuss study implementation issues and consider progress reports;

7. Review and critique conclusions reached and interim products; and

8. Review and approve drafts of all Track A and Track B study reports; and

9. Draft the final project report in consultation with the Track A and B contractors, submit it to the MMC Board for review and comment by relevant stakeholders, modify the draft as appropriate, and submit the final document to the MMC Board for approval and official transmittal to FEMA.

Project Manager

In addition to the persons on the NIBS staff responsible for administrative matters, a technical consultant will be engaged to serve as the Project Manager who will monitor the work of the Track A and B contractors, document project progress reports, ensure research entity cooperation, encourage timely completion of tasks and monitor expenditures in relation to progress for process, identify issues to be considered by the PMC, and implement PMC decisions. The Project Manager, working with the NIBS staff, will plan and arrange for all meetings including two joint meetings involving the PMC, MMC Board of Direction, and Technical Advisory Group.

Technical Advisory Group

Because the study will benefit from suggestions from a broad range of stakeholders and other interested parties, the Project Manager will develop, with the assistance of the MMC Board and PMC, a list of such individuals who then will be invited by the Board to serve as members of a Technical Advisory Group. The TAG will include “mitigation stakeholders” such as MMC member organizations, state and local government mitigation managers, insurance professionals, loss estimation specialists, and researchers from related fields and will be sent regular reports on project progress. The TAG also will be invited to participate in two meetings with the MMC Board and PMC to discuss project scope and the draft final reports. TAG members will not be compensated and their travel expenses will be not be reimbursed as a general rule (however, travel assistance may be necessary to guarantee the participation of key individuals).

Research/Analysis Entities

The research/analysis entities to conduct the Track A and B studies will be selected based on the quality of their proposals, results of interviews, comments of references, and understanding of the project as demonstrated by the proposal. Separate proposals will be accepted from single contractors for both the Track A and Track B studies; however, a contractor who submits such a proposal will be expected to document specific advantages that would result from conduct of both sets of studies by a single entity. Contractors will be encouraged to team with university faculty to afford qualified graduate students an opportunity to combine work on a dissertation with project work. The following are the specific criteria that will be used for judging proposals:

1. Technical Merit (30 points) – The robustness of the proposal for selection of samples, knowledge of existing data, scheme for collecting additional data, expertise in using
economic and loss estimation modeling techniques, proposed presentation of results, and understanding of the purpose and content of the final report as demonstrated by a description of the final report.

2. Team Qualifications (20 points) – Education, skills, and experience of project team members with respect to the steps in the process proposed and demonstrated expertise in social science, economics modeling, benefit-cost analysis, policy analysis, loss estimation, statistics, and the hazards of flood, wind, and earthquake. Members of the MMC Panel that prepared this report will not be barred from participating as part of a contracting team; however, their work in the development of this report will not be considered in evaluating team qualifications. In the interest of the independence of the assessment, extensive team experience in evaluating FEMA-funded mitigation activities is not considered to be desirable.

3. Track Record (15 points) – Evidence regarding the ability of the members of the proposed team to work together, to meet contract deadlines, and to produce the desired product.

4. Budget Allocation (10 points) – The degree to which the proposal links tasks with resource needs, the certainty with which resource allocations can be determined to be adequate for the work proposed, and the amount of work to be accomplished within the budget amount. Note that it will be stipulated that the amount of proposals cannot exceed the amount specified in the request for such proposals, and proposals exceeding the amount available will be rejected without further consideration.

5. Project Management (10 points) – Evidence of team leadership, experience with project management and the supervision of multidisciplinary workers; knowledge of topics pertinent to the study; and the techniques proposed to monitor progress and ensure the quality of the data and accuracy of the analyses.

6. Project Coordination (10 points) – The specific measures proposed to ensure that the Track A and Track B contractors collect and share compatible data and collaborate on analytical methods, results, and reports.

7. Quality and Clarity of Writing (5 points) – As evidenced by the proposal’s description of study content and final reports.

**STUDY TASKS**

**Task 1, Detailed Work Plans**

The Track A and B contractors will be required to prepare work plans that describe, among other things, how those working on each track will collaborate and share information. These work plan also must include:

C A detailed description of how specific tasks will be conducted;

C A schedule with appropriate milestones indicated;

C A description of the methodology and data sources to be used, variables to be measured, and data collection methods; and
C Resource allocations by task.

The detailed work plans will be due four weeks after execution of contractual agreements. The contractors will meet with the Project Manager and PMC within 14 days following submittal of the work plans to discuss the plans and draft any necessary modifications. The PMC must approve the work plans prior to the initiation of further work.

Task 2, Scoping Studies

The Track A contractor will summarize recent and current FEMA work on loss estimation, cost-effectiveness determinations, and benefit/cost methodologies. Reports that provide guidance and documentation to substantiate the monetary value of intangible benefits and costs will be identified. The product will be a working paper summarizing the information.

The Track B contractor will conduct an integrative, synthesizing literature review of procedures and methodologies used in the United States and in other countries to assess the benefits and costs associated with various programs and policies with a special emphasis on those that focus on hazards and the environment. The bibliography and references section of this report serves as a starting point for this task. The Track B contractor also will prepare a comprehensive list of process and project mitigation activities, divided into categories, for use in both the Track A and B studies (see Table 5).

The contractors for Tracks A and B will review and critique each other’s products and draft an interim report containing the two products as well as a joint outline of the final reports on Tracks A and B. The contractors for Tracks A and B also may include in the interim report proposed work plan modifications based on their initial findings. The interim report will be due within 10 weeks of the effective date of the contracts and will serve as the basis for a joint meeting of the MMC Board, Project Management Committee, Technical Advisory Committee, and federal agency stakeholders.

Task 3A, Track A Analysis – Basic Benefit/Cost Analysis of Specific Mitigation Activities Commonly Employed to Reduce Losses Due to Wind, Earthquake, and Flood

The purpose of the Track A study is to estimate through modeling the savings realized from FEMA expenditures on mitigation activities. This study track is quantitative and shall be performed on a disproportionately stratified representative statistical sample of FEMA-funded mitigation activities. Costs, benefits, and other relevant variables will be measured or estimated at the following geographic levels:

C The jurisdiction covered by the mitigation activity,

C The state, and

C The nation.

1 The mitigation activities chosen for the Track A study should be completed or sufficiently advanced that completion is assured and that both direct and indirect costs and benefits can be estimated. This would include estimates of negative benefits and costs and/or benefits that will not be realized until after a project is completed.
Task 3A will be completed within 18 months of the starting date of the contract.

**Subtask 3A.1, List the Population.** The proposed independent assessment is limited to three hazards – wind, earthquake, and flood – to minimize its cost, and because these hazards represent a significant portion of the FEMA investment in mitigation. The contractor shall develop a comprehensive list of funded and process and project mitigation activities. This will be done in concert with FEMA staff and will include mitigation activities funded by the Hazards Mitigation Grants Program (HMGP) including funds for planning and statewide matters, Flood Mitigation Assistance, and Project Impact (now pre-disaster mitigation under the Disaster Mitigation Act of 2000).

**Subtask 3A.2, Identify Mitigation Type.** The list of mitigation activities identified in Task 3A.1 will be grouped (stratified) into the two “process” and “project” mitigation activities. These two groups shall be further subdivided into relevant subcategories of mitigation activities.

**Subtask 3A.3, Identify and Categorize Hazard Exposure.** The contractor will classify (stratify) each of the mitigation activities listed in Subtask 3A.1 in terms of high, medium, and low exposure for each of the hazards that the activity addresses. Hazard exposure will be defined in collaboration with the Track B contractor and will require review and approval by the PMC.

**Subtask 3A.4, Select Sampling Fractions and Samples.** The contractor shall list the activities in each stratum of FEMA mitigation activities in each of the resulting categories that result when the following stratification criteria are taken into account: process mitigation type, project mitigation type, hazard type, and hazard exposure. The Track A contractor then will determine an appropriate sampling fraction – the minimum number needed to ensure a statistically representative sample at an adequate level of power – for each stratum of this population and randomly select for inclusion in the sample that number of mitigation activities. Some cells with too few cases in them may be excluded from the study analyses but only after consultation with the PMC.

**Subtask 3A.5, Consult with State Hazard Mitigation Officers.** After selection of the study sample but before initiating any contact with recipients of mitigation funds, the contractor, in conjunction with the Track B contractor, will contact the State Hazard Mitigation Officers of the affected states to request data collected at the state level and to obtain additional information on process and project activities and contact information for grant recipients.

**Subtask 3A.6, Measure Costs for Activities in the Sample.** The costs of mitigation activities shall be determined by summing the FEMA, state, local, and private dollars spent on the activity. Costs include dollars spent for administration and maintenance of mitigation activities even if those costs must be estimated. The cost for each contributing entity will be compared to the resulting benefits to describe the leverage achieved through funding cooperation. New data on indirect economic impacts will not be developed, but guidance on indirect impacts developed by the Track B study will be used to supplement this task (see Subtask 3B.9).

**Subtask 3A.7, Estimate Expected Benefits for Activities in the Sample.** The benefits of each mitigation activity shall be estimated. Expected benefits are losses avoided because of the mitigation activity for hazard events of different intensities multiplied by the probability of occurrence of each of these events. Losses avoided shall include but not be limited to: reduced loss of life, injury, and damage to property (including historic properties); reduced impacts on environmental, social, and recreational values; reduced community disruption and
business interruption; and future expenditures on disaster relief. Benefit estimates should consider the results of Track B studies and information gleaned from published reports. It is recognized that in-depth valuation studies will very likely not be possible within the scope of the Track A study. Benefits shall be expressed as dollar values and in actual units (e.g., the number of lives saved, acres of habitat reserved as open space, historical structures preserved or other values achieved as a result of the mitigation activities) and estimated for the short (5 years), intermediate (20 years), and long term (50 and 100 years).

Subtask 3A.8, Measure Other Variables That Should Be Taken Into Account in Explaining Mitigation Outcomes. The contractor shall gather data on relevant variables for use in statical analysis for each case included in the Track A study. These variables shall be those that are readily available from governmental and other sources and that the existing research record shows to be important for benefit and costs outcomes.

Subtask 3A.9, Analyze the Data. The data will be analyzed in two ways: (a) the contractor shall use appropriate descriptive and inferential statistics to determine the total dollar costs and total future savings in each of the strata included in the Track A study overall and by mitigation type, hazard type, etc. and (b) the contractor shall conduct analyses at levels of aggregation including the community, region, and nation.

Subtask 3A.10, Sensitivity Analyses. Recognizing that there is considerable uncertainty associated with the estimation of costs and benefits and the variables considered, the contractor will undertake a series of sensitivity analyses to determine the robustness of the analytic findings as one changes the values of certain variables. The contractor shall use appropriate analysis and other statistical techniques (e.g., multiple regression) to determine the relative change in the benefits and costs and their ratio as a function of the relevant variables in the model. The results of sensitivity analyses will be reported.

Subtask 3A.11, Compile Results. The contractor shall compile the results in a way to allow comparisons of benefits and costs in monetary and, wherever possible, actual values and shall aggregate the results in combinations of interest to various decision makers at the mitigation activity, community, state, and national levels. The contractor shall compile the results in conjunction with the Track B contractor. Values should be reported as monetized estimates and as actual units and with and without the multipliers determined in Track B.

Subtask 3A.12, Prepare Final Report. The contractor, in cooperation with the Track B contractor, shall prepare a final report that presents study results in a manner that responds to the needs of policy makers concerned with the effectiveness of mitigation programs. The report will feature an executive summary, text describing the study results (with tables and graphics), and technical appendices that provide full study documentation and describe the details of the methodology, data collection, sample selection, analysis, and all conclusions regarding future savings.

Task 3B, Track B: Enhanced Benefit-Cost Analysis, Community Level

The Track B study is qualitative and will be performed using a purposive (i.e., selected based on criteria that are relevant to the purposes of this study) theoretical sample of communities – and all the FEMA-supported mitigation activities within them – to explore mitigation activities and the interactions between them and other relevant variables in more depth than is possible in the Track A study (see Appendix D). Task 3B will be completed within 18 months of the starting date of the contract.
Subtask 3B.1, Select Communities for Study. It is unlikely that the Track A study will be able to estimate the additional savings that result from the interaction among several mitigation activities over time. Thus, the Track B study is intended to estimate, in a smaller sample of communities, the additional savings that result from FEMA funding and the savings from mitigation activities implemented without FEMA funding, but undertaken because of FEMA’s efforts. The contractor shall select study communities from among two populations: (a) hazard-prone communities defined as those communities that have received funding under FEMA’s pre-disaster mitigation Project Impact program and (b) communities that have received significant Hazard Mitigation Grant Program funds as a result of a federally declared disaster since 1990 and/or have received Flood Mitigation Assistance since the inception of the program 1996.

Communities will be further categorized and selected according to the following criteria:

C Communities whose most significant vulnerabilities originate from one of the three primary hazards: flood, hurricane (including both wind and flood), and earthquake;

C Communities with different levels of hazard exposure ranging from moderate to high;

C Communities in which the mitigation measures employed are those most commonly used for their particular hazards;

C Communities in which those measures have been implemented on a wide enough scale that sufficient data are available; and

C Other considerations being equal, communities for which data already exist (e.g., loss estimation models, analyses on the costs and benefits of alternative mitigation measures, and data on the actual costs of implementing mitigation measures).

Candidate communities will be discussed with the PMC before data collection begins.

Subtask 3B.2, Identify and Categorize Hazard Exposure. The contractor will define high and moderate exposures for each hazard in collaboration with the Track A contractor and the PMC.

Subtask 3B.3, Measure Costs of Mitigation Efforts in the Community. The costs for mitigation will include FEMA, other federal agency, state, local, and private dollars spent on the mitigation activities. This “dollars-spent” assessment should include administrative and maintenance costs and indirect costs. Costs also should include relevant opportunity costs.¹ The contractor should begin with one community to determine the necessary level of detail to get the insight needed before deciding on the number of communities and the depth of studies to be undertaken. Estimates of costs made at the time of grant approvals should be updated to reflect actual experience.

Subtask 3B.4, Estimate Expected Benefits of Mitigation Efforts in the Community. The benefits of mitigation activities shall be estimated. Expected benefits are the losses avoided because of a mitigation activity for hazard events of different intensities, multiplied by the probability of each of these events occurring. Losses avoided shall include but not be limited to: reduced loss of life, injury, and damage to property (including historic properties); reduced

¹ The value of alternatives foregone to achieve the mitigation activity.
impacts on environmental, social, and recreational values; reduced community disruption and business interruption; and future expenditures on disaster relief. This task should explore how FEMA-funded mitigation influences and instigates mitigation projects funded by others; therefore, all mitigation activities in a community should be considered rather than only FEMA-funded activities. In addition, all hazards should be considered even though communities will be selected based on three major hazards and their associated mitigation activities. The multiplying effect of FEMA investments should be examined.

Subtask 3B.5, Devise Strategies for Taking Into Account Both Process and Project Mitigation Activities. The Track B contractor shall evaluate the interaction between mitigation activities for various hazards. In this context, the contractor shall develop a model that describes the relation between outputs from process mitigation activities and outcomes from project (and some process) mitigation activities. The analysis should describe causality relationships that lead to reductions in losses (see Appendix D).

Subtask 3B.6, Consult with State Hazard Mitigation Officers. After selection of the study sample but before initiating any contact with recipients of mitigation funds, the contractor, in conjunction with the Track A contractor, will contact the State Hazard Mitigation Officers of the affected states to request data collected at the state level and to obtain additional information on process and project activities and contact information for grant recipients.

Subtask 3B.7, Assess the Impacts of Other Variables. The contractor shall appropriately examine the importance of variables that potentially affect mitigation program success. The variables considered should be those for which publicly held data are readily available and those that existing research shows to be important to benefit and costs outcomes. Growth rate and availability of development plans, economic and education levels, local capability, characteristics of applicant and administrative agencies, and presence of dedicated leaders are among the kinds of variables to be considered.

Subtask 3B.8, Document Non-FEMA Funding. The contractor shall document all non-FEMA funds used to carry out mitigation activities. These contributions should be analyzed to measure the effects of FEMA leadership and the leveraging effect of FEMA grant dollars.

Subtask 3B.9, Analyze the Data. The data will be analyzed in two ways: (a) the contractor shall use appropriate descriptive and inferential statistics to determine the total dollar costs and total future savings in each of the strata included in the Track A study overall and by mitigation type, hazard type, etc. and (b) the contractor shall determine the multiplier effect that can be applied to savings determined in Track A.

Subtask 3B.10, Conduct Sensitivity Analyses. Recognizing that there is considerable uncertainty associated with the estimation of costs and benefits, the contractor shall determine to robustness of the analytic findings. The contractor shall use appropriate analysis techniques to determine the relative change in the benefits and costs and their ratios as a function of the relevant variables in the model.

Subtask 3B.11, Compile Results. The contractor shall compile the results in a way to allow comparisons of benefits and costs in monetary and, wherever possible, actual values and shall aggregate the results in combinations of interest to various decision makers at the mitigation activity, community, state, and national levels. The contractor shall compile the results in conjunction with the Track A contractor. Values should be reported as monetized estimates and as actual units.
Subtask 3B.12, Prepare Final Report. The contractor, in cooperation with the Track A contractor, shall prepare a final report that presents study results in a manner that responds to the needs of policy makers concerned with the effectiveness of mitigation programs. The report will feature an executive summary, text describing the study results (with tables and graphics), and technical appendices that provide full study documentation and describe the details of the methodology, data collection, sample selection, analysis, and all conclusions regarding future savings.

Task 4, Meetings and Reporting

The Track A and B contractors shall complete the following subtasks:

1. Provide monthly reports to the Project Manager regarding progress for each task, status of expenditures relative to progress, issues that affect the project methodology, scope of work, schedule, coordination with the other contractor, changes in personnel, and other issues that affect the successful completion of the study.

2. Provide written quarterly reports to the PMC on substantive issues regarding the study. Quarterly reports will supersede the need for a monthly report.

3. Meet quarterly with the PMC and semi-annually with the MMC Board. The first meeting will be one month after execution of contracts. The contractors will be represented by members of their team who are qualified to discuss the methodology and empowered to make decisions regarding work plan modifications.

4. Present materials and participate in workshops held after completion of Task 2 and when the draft final reports are issued.

5. Submit to the MMC staff monthly invoices for work performed.

Task 5, Presentation and Defense of Project

After the final project report has been completed and transmitted to FEMA, qualified representatives of the contractors shall be available for a one-day in Washington, D.C., to discuss the methodology, data collection, analysis and conclusions with staff from FEMA and other interested federal agencies. The contractors also shall be available for consultation and to respond to specific questions by phone and e-mail for a period of two years following completion of the project.

DATA COLLECTION GUIDANCE

In the context of data collection efforts, the Track A and B contractors will be expected to:

C Review the list of factors included in the definitions of benefits and costs, describe the measures needed to quantify them, and identify data sources and/or analytical models that contain those measures.

C Rely on the NEMIS database, FEMA, state and local project files, lists of repetitively flooded properties, lists of Project Impact communities, and consult with the FEMA TAC contractors. It is assumed that FEMA will provide access to these databases and contractors during the proposal preparation stage.
C Use available databases and data from published reports to the greatest extent possible and minimize the collection of original data.

C Contractors shall use the same hazard definitions expressed by intensity levels and probability of occurrence.

**STUDY GUIDANCE**

In conducting the Track A and B studies, the contractors shall function with the following in mind:

1. The need to comply with the guidance in OMB Circular A-94.

2. The social net benefits taken into account should not be confined only to those that accrue to the federal government. The studies should describe benefits and costs of mitigation in monetary values to the extent possible. Benefits include but are not limited to: avoided damage, disruption, and displacement of people, businesses, and government; death and injuries; and health and psycho-social impacts on humans and psychological trauma. In both the Track A and B studies, intangible savings should be described and quantified by physical measures and monetized to the extent possible in a consistent manner. Examples of losses that cannot be monetized can be used to illustrate the nature and importance of these savings. For example, actual loss of lives, cultural materials (collections of artifacts, art, books, and historic and architecturally important buildings); family heirlooms, records, and photographs; research materials and long-term experiments; business, medical, academic and government records; and environmental and recreational amenities might be described.

3. Alternative methods for monetizing benefits and costs (including the contingent valuation, travel cost, hedonic price methods, least cost alternative, shadow pricing and proxy values) can be used, but estimates should be based on documented examples and simple rules rather than detailed studies (see Appendix C).

4. The number of lives saved per dollar of mitigation cost is an indicator of mitigation effectiveness. Life loss would be monetized for economic comparisons using a range of values for life to describe the sensitivity of benefits to different life-value assumptions.

5. A broad description of benefits and costs of mitigation projects and processes is necessary to understanding fully the importance of FEMA mitigation funding to U.S. society, but the results should be presented in a format to allow the interested parties to tally them in an appropriate manner (see Appendix E).

6. A sensitivity analysis should be done on all key variables to elucidate the effect of uncertainty and other assumptions on the calculation. Discount rate variations including the rate specified by OMB Circular A-94 and rate of “0” shall be considered.

7. The Track A and B final reports should describe the anticipated benefits and cost for several different scenarios. Each should describe the benefits of mitigation expected from events such as a 100-year flood, a Category 3 hurricane, and an earthquake with a recurrence of once in 500 years.
8. OMB recommends against including the secondary effects of federal expenditures on employment, but increased employment and output are important considerations at the community level so these secondary effects should be determined.

REPORTING GUIDANCE

The Track A and B contractors’ final report should be sensitive to the needs of a variety of interested agencies and individuals including the following:

- Federal Emergency Management Agency (for program evaluation and budgeting purposes)
- Office of Management and Budget (for budget projections)
- Congressional Budget Office (for cost projections and budget studies)
- Government Accounting Office (for program evaluation purposes)
- Members of Congress (for program authorization and appropriations and program impacts on home Congressional districts and states)
- Appropriations Committees (for information)
- State Officials (for mitigation planning)
- County/City Officials (for mitigation planning and evaluation activities)

Based on the contractors’ report, the PMC and Project Manager will draft the overall project report presenting the major conclusions of the study, any recommendations that may be appropriate, and an overview of the project results. This project report will be written in a style that will be useful to FEMA in reporting to members of Congress and congressional committees and agency staff members. The results will be presented so that individuals can readily identify the benefits and costs relevant to their interests. Persons interested in broadly defined savings can consider direct and indirect and tangible and intangible impacts including transfer losses on a city, Congressional district, state, or the nation as a whole.

CONFIDENTIALITY OF STUDIES

The contractors will maintain the confidentiality of communities and community contacts. The purpose of both study tracks is to support policy analysis regarding the efficacy of federal mitigation programs carried out by state and local agencies and certain nonprofit entities. The report is intended for use by members of the Administration and Congress and their staff when considering appropriation decisions. Completed work materials and databases will be public documents. The study methodology must be transparent – that is, it must describe data sources, collection methods, and analytical methods to allow FEMA, the GAO and/or the CBO to evaluate or replicate the work. At the same time, confidentiality protection must be extended to individuals who provide data for this study. The databases compiled as part of this project are intended to be available for related research activities and should be provided as part of the final report on a CD in a manipulatable format. Original data shall be provided to and maintained by NIBS. Contractors are required to adhere to all relevant Department of Health and Human Services requirements involving the protection of human subjects, as set out in CFR Title 45, Part 46 (see Appendix B). Study proposals should include discussions on
measures that will be undertaken to protect the confidentiality of individuals providing data for the study.

**SCHEDULE**
It is anticipated that the independent assessment will require approximately 24 months to complete. Interim reports will be provided to FEMA on at least a quarterly basis and at identified milestones in project progress.
Glossary

**Annualized Benefits and Costs** – The value of benefits and costs based on the probability the benefit or cost will be realized in a given year.

**Alternative Valuation Methods** – Techniques devised by economists to measure the monetary value of non marketed goods.

**Assets** – Lives, buildings, utilities and transportation systems, cultural, social …

**Benefit** – Any increase in utility or well-being to an individual, group or society associated with an action or choice. Bounded from below by price. It is synonymous with value in economic theory. Benefits and costs are complementary – a cost is a negative benefit, since costs decrease well-being and benefits increase well-being. This is the source of much confusion in BCA, since different accounting methods will assign the same impact as a benefit or a cost. It is also the source of double counting and should be avoided. Why identify them separately? Because benefits and costs usually are separated by individuals over space and over time. (From Ganderton)

**Benefit/Cost Analysis** – A systematic quantitative method of assessing the desirability of government projects or policies when it is important to take a long view of future effects and a broad view of possible side-effects. Benefit/cost analysis is recommended as the technique to use in a formal economic analysis of government programs or projects. (From OMB A-94)

**Cost** – Any reduction in utility or well-being to an individual, group or society associated with an action or choice. Generally it is not the same as price, which bounds cost from above. (From Ganderton)

**Cost Effective** – The least cost alternative means for achieving the same stream of benefits or a given objective. Cost-effectiveness analysis is less comprehensive than benefit/cost analysis, but can be appropriate when the benefits from competing alternatives are the same or where a policy decision has been made that the benefits must be provided. It can be used to compare programs with identical costs but differing benefits. FEMA guidance has defined cost-effective as the benefits equal to or exceeding the costs. (From OMB A-94)

**Damage** – Damage refers to physical destruction measured by physical indicators such as the number of deaths and injuries or the number of buildings destroyed. When valued in monetary terms, damages become direct losses. (From Litan 1999)

**Discount Rate** – Discount rate is the interest rate used in calculating the present value of expected yearly benefits and costs. Net present value represents the discounted value of future benefits and costs. Discounting reflects the time value of money and the view that benefits and costs are worth more when they are experienced sooner. OMB determines the discount rate for analysis of federally funded projects.

**Empirical** – Relying on experience or observation, capable of being verified or disproved by observation or experiment.

**Exposure** – People, property, systems, or functions at risk of loss exposed to hazards.
Hazard – An act or phenomenon that has the potential to produce harm or other undesirable consequences to some person or thing.

Impacts – The impacts of a disaster include market-based and non market-based effects. Market-based impacts include destruction of property and a reduction in income and sales (Litan 1999). Nonmarket effects include environmental consequences and psychological effects suffered by persons involved in a disaster (from Ganderton)

Loss – Any reduction in value, or well-being to individuals, groups or society. A loss is a cost. Losses avoided are benefits.

Direct Losses – Losses linked directly to a hazard event including all damages and employment losses due directly to the closure of damaged facilities.

Indirect Losses – All losses other than direct losses. Indirect losses include economic losses due to dislocations in undamaged factories or commercial ventures, banking, and insurance as well as non financial losses such as loss of historical resources, pain, and suffering.

Market Price – The price for which a good is bought and sold in a market. If restrictive conditions are satisfied, this price may be used to estimate the economic value of the good. Or, the market price may need to be corrected, a ‘shadow price’ derived, in order for the economic value of the good to be estimated. (From Handmer 1996)

Maximum Foreseeable Loss – An estimate of losses assuming the worst combination damage and disruption to a business. This estimate allows consideration of the worst possible consequences.

Mitigation – All actions taken to reduce or eliminate long-term risk to people and property from hazards and their effects. Mitigation activities contrast with short-term risk-reducing actions such as preparedness, response and recovery measures and risk spreading measures such as insurance.

Multiplier – The ratio between the direct effect on output or employment and the full effect including the effects of second order rounds or spending. (From OMB A-94)

Net Present Value – The discounted monetized value of expected net benefits (i.e., benefits minus costs). This is the standard criterion for deciding whether a government program can be justified on economic principles. Net present value is compute by assigning monetary values to benefits and costs, discounting future benefits and costs using an appropriate discount rate, and subtracting the sum total of discounted costs from the sum total of discounted benefits. (From OMB A-94)

Opportunity Cost – The value of alternatives foregone to achieve the mitigation activity. It can be thought of as the value of the good or service in its best alternative use. For example, the value of a park in its next highest alternative use as an industrial area. (From Handmer 1996)

Present Value – The value of a stream of benefits or costs when discounted back to the present time. (From Handmer 1996)
**Process Mitigation** – Indirect mitigation activities that lead to policies, practices and projects that reduce risk. They include efforts to assess hazards, vulnerability and risk; conduct planning to identify projects, policies and practices and set priorities; educate decision-makers and build constituencies and political will; and to facilitate the selection, design, funding and construction of projects.

**Project Mitigation** – Project mitigation includes measures to avoid or reduce damage resulting from hazard events. They include projects to elevate, acquire and/or relocate buildings, lifelines and structures threatened by floods, strengthen buildings to resist earthquake or wind forces, and to improve drainage and land conditions.

**Risk** – The probability that the potential harm or undesirable consequences of a hazard will be realized; the convolution of the hazard, vulnerability (or fragility), and asset exposure.

**Saving** – Formally saving is the reduction in present consumption to increase future consumption. It defers benefits from the present to the future, and consequently allows temporal shifting of benefits. However, in some contexts, the word is used to mean losses avoided, so implying a benefit. (From Ganderton)

**Shadow Prices** – If a market in a good is not perfectly competitive, then market prices will not reflect the opportunity costs of that good. The price of the good, as corrected to equal its opportunity cost, is termed its shadow price. (From Handmer 1996)

**Vulnerability** – The susceptibility to physical injury, harm, damage, or economic loss.
Appendix A

Federal Disaster Assistance Programs

When a natural disaster strikes the federal government incurs expenses through a number of programs. According to the Senate Bipartisan Task Force on Funding Disaster Relief (1995) as reported by the Government Accounting Office (GAO/T-RCED-98-139, pp. 1-2), federal agencies obligated $119.7 billion (in constant 1993 dollars) for disaster assistance (recovery, mitigation, preparedness, and response) during fiscal years 1977 through 1993. FEMA accounted for only 22 percent of this amount with the remainder spread across many federal agencies including the Small Business Administration (SBA), the U.S. Army Corps of Engineers (COE), and the Cabinet-level departments responsible for agriculture (DOA), transportation (DOT), interior (DOI), commerce (DOC), and housing and urban development (HUD). Post-disaster recovery accounted for $87 billion or about three-quarters of the $119.7 billion.

Of the $87 billion, about $55.3 billion consisted of recovery loans primarily made by the SBA and Department of Agriculture. (About three-quarters of the amount lent will be repaid.) FEMA accounted for about $10.2 billion, DOT, $4.1 billion, and $16 billion were obligated by USDA to compensate farmers for production losses.

Mitigation expenditures accounted for about $27 billion of the $119.7 billion. The vast majority of these funds, $25 billion were made by the COE on flood control and coastal erosion control facilities. The remainder was spent by the National Flood Insurance Program for establishing floodplain management and building standards and by the National Earthquake Hazards Reduction Program (NEHRP) for earthquake research and related activities. In recent years, because of FEMA expenditures authorized by the Stafford Act Section 404 increased from 10 percent of public assistance to 15 percent of all assistance categories, FEMA’s mitigation expenditures would be a larger portion of the total.

Immediate response expenditures, spent largely by FEMA, amounted to $3.4 billion; and

Preparedness activities received $2.3 billion largely from FEMA. (GAO, pp. 3-5)

FEMA’s expenditures are authorized by several sections of the Stafford Act. They are shared with the states and local governments. The federal share is at least 75 percent of public assistance projects (Section 406). However, the President can increase the federal share. The federal share following the Northridge earthquake was 90 percent and following Hurricane Andrew, 100 percent. Relevant Stafford Act sections are the following:

Section 403 – Essential Assistance to Meet Immediate Threats
Section 404 – Hazard Mitigation Grant Program
Section 405 – Repairs to Federal Facilities
Section 406 – Public Assistance Program
Section 407 – Debris Removal
Section 408 – Temporary Housing Assistance
Section 410 – Unemployment Assistance
Section 411 – Individual and Family Grants
Section 412 – Food Coupons and Distribution
Section 413 – Provision of Food Commodities
Section 414 – Relocation Assistance
Section 415 – Legal Services
Section 416 – Crisis Counseling
Section 417 – Community Disaster Loans
Section 418 – Emergency Communications
Section 419 – Emergency Public Transportation
Section 502 – Federal Emergency Assistance
Section 601 – Federal Emergency Preparedness

Small Business Administration
SBA Home Repair Loans

Department of Housing and Urban Development
Appendix B

CFR 44 Section 206.434(b)(5)

The regulations guiding the administration of Section 404 mitigation grants are contained in the Code of Federal Regulations (CFR), Title 44, Volume 1, Section 206.43, et seq. Section 206.434, which describes the eligibility requirements for projects, addresses cost-effectiveness as follows in paragraph (b)(5):

(5) Be cost-effective and substantially reduce the risk of future damage, hardship, loss, or suffering resulting from a major disaster. The grantee must demonstrate this by documenting that the project;

(i) Addresses a problem that has been repetitive, or a problem that poses a significant risk to public health and safety if left unsolved,

(ii) Will not cost more than the anticipated value of the reduction in both direct damages and subsequent negative impacts to the area if future disasters were to occur. Both costs and benefits will be computed on a net present value basis,

(iii) Has been determined to be the most practical, effective, and environmentally sound alternative after consideration of a range of options,

(iv) Contributes, to the extent practicable, to a long-term solution to the problem it is intended to address,

(v) Considers long-term changes to the areas and entities it protects, and has manageable future maintenance and modification requirements.
Appendix C

Refine Benefit and Cost Methodologies

Introduction

Members of the Panel on Assessment of Savings from Mitigation Activities prepared background documents to focus panel discussions on particularly vexing issues. Dr. Philip T. Ganderton drafted this paper with assistance from Carol Taylor West, Kathleen Tierney, David Godschalk, Howard Kunreuther, Kim Shoaf and Tom Tobin. This group was given the following Charge:

1. Refine the cost and benefit attributes to consider when assessing the net societal benefits.
2. Agree on the methods to measure and value each attribute.
3. Describe the data needed to establish attribute value.
4. Describe appropriate sampling methods.

Undertaking a cost-benefit analysis (CBA) is relatively simple as the menu taken from Boardman, Greenberg, Vining and Weimer, *Cost-Benefit Analysis*, (a standard textbook in the field, page 7) suggests:

1. Decide whose benefits and costs count (standing)
2. Catalog potential (physical) impacts and select measurement indicators.
3. Predict quantitative impacts over life of the project.
4. Monetize (attach dollar values to) all impacts.
5. Discount for time to find present values.
6. Sum up the discounted benefits and costs.
7. Perform sensitivity analysis.

While this list is illustrative, it is by no means a complete statement of the current state of the art of BCA and fails to mention nearly all the contentious issues surrounding the use, and details, of the method – for example, point 5 is clearly not this simple! However, the essential elements are present and provide a starting point for a brief discussion of the strengths and weaknesses of the method.
Identifying standing is clearly necessary, but difficult, since there are practical limits to identifying and acknowledging all individuals who might enjoy gains, or suffer losses, as a result of a hazard, or mitigation activity. Generally analysts attempt to identify those affected directly, and those affected indirectly. While in many cases the direct affects are larger than the indirect ones, there is evidence from the environmental economics literature that the values placed on the preservation of certain natural resources by the wider society (so called existence values) can be huge, and orders of magnitude larger than any direct values.

Both observable, physical and non-physical impacts may arise from hazards and their mitigation. There may also be unobservable impacts. Potential gains and losses to all those with standing must be catalogued with an attempt to categorize them as benefits or costs, and with regard to their nature: Are they monetized, and of those not monetized which ones could be monetized? Methods exist to monetize impacts that are not traded in markets, and for which prices or shadow prices cannot be observed. However they are controversial, with much attention going to the contingent valuation method (CVM).

Discounting is highly contentious, since there are many theoretical and practical arguments for the choice of one discount rate over another. Since many mitigation activities will have long-term impacts, and use public funds, it would seem appropriate to use a long term government interest rate for the discount rate, however we would want our contractor to investigate the issues, and offer some sensitivity analysis to alternative discount rates (including zero, perhaps.)

In many analyses, uncertainty is captured in the discount rate sensitivity analysis. That is, a factor to capture uncertainty is added to the discount rate in the analysis. There are other, more preferable, ways to incorporate uncertainty into BCA that require considerably more data and information, such as specification of probability and loss amount distributions when known or estimable.

The contractor would be required to review the current state of the art in BCA, and offer evidence to support all analytical and methodological choices made in the study.

Details from Charge

Refine the Cost and Benefit Attributes to Consider when Assessing the Net Societal Benefits

As discussed above, some events or outcomes are viewed as benefits by some individuals but costs by others. That is, the nature of a value can depend on the person experiencing that change. For example, the relocation of residences from the 100-year flood plain may produce benefits of reduced injury and property damage to residents, yet they may lose their connection to land that was historically and culturally important to them, thereby creating a cost in terms of psychological or emotional pain. If these benefits and costs are borne by the same individuals, BCA can easily resolve the conflict by measuring and including a net benefit of relocation. However, if these values are borne by different folk, such that the costs are incurred by those not being relocated and receiving the safety benefits, then there are two separate entries in the BCA—the gains to those relocated, and the losses to those who lose cultural values. Pragmatically, each change in well-being must be accounted for as either a benefit (gain) or a
cost (loss) in order to conduct analysis, however so long as the sign is correct (gain = +value, loss = - value), it is irrelevant which category the value belongs to.

With this in mind, the following is a (partial) list of potential benefits and costs that should be considered when determining the net present value of mitigation.

Benefits of Mitigation – Most benefits of mitigation are costs and losses avoided through the reduction in loss probabilities and a reduction in loss amounts/value. Such as reduced:

C Loss of life, injury and pain
C Property destruction and damage
C Community disruption, personal and local infrastructure.
C Business interruption, including closures, shutdowns, un- (and under-) employment.
C Loss of culturally and historically important items.
C Expenditure on disaster relief by both governments and private organizations.

But benefits may also include increased awareness by communities of hazards, their impacts and avoidance.

Costs of Mitigation – The costs of mitigation include:

C Direct expenditures on relocation, construction and transportation.
C Costs generated by rules and regulations setup in the name of hazard mitigation (e.g., lower property values due to new zoning)
C Denial of access to economic resources (environmental) due to zoning
C Increased business costs from mitigation-related safety regulations

General Types of Benefits and Costs – It may be appropriate to construct a general taxonomy of impacts such as:

C Direct impacts (example: strengthening an electricity generating plant reduces the damage in an earthquake, reducing down time.)
C Indirect impacts (example: power outages are shorter and so business disruption is less during and after an earthquake.)
C Traditionally, nonmonetized impacts is a catch-all category that includes all impacts that are difficult to measure, including reduction in morbidity and mortality, cultural values, even environmental resource impacts.
C Secondary impacts (distinguished from indirect impacts by space and/or time)
Transfers – There is mention in the Phase I draft of transfers. Theoretically, unless transfers generate so-called “transactions costs” they are not included in a BCA, since who enjoys or suffers gains and losses is “irrelevant.” If one person enjoys a benefit as a result of the transfer of an economic resource, or wealth, from another these just cancel each other out. For transfers to be important to us we must feel that the distribution of impacts to be important – it’s not enough to know that benefits outweigh costs, but that those who benefit are particular people or groups, and those that suffer losses are particular people.

Agree on the Methods to Measure and Value Each Attribute

There are a number of methods available to measure changes in value. However, the theoretical value required is the shadow price. This reflects the ultimate change in well-being to those affected individuals. (Note the use of the word price does not necessarily imply dollars.) Only under very strict conditions do observed market prices accurately reflect these shadow prices. In cases where actions or policies do not result in, or from, trades in markets, market prices are not even available, and so shadow prices must be measured, or inferred by indirect means.

Where costs or benefits are already traded in existing markets, market prices can be used, with the possible exception of known market failures, such as monopoly, where the shadow price would differ from the market price, but may be inferred from observed prices.

Indirect methods for estimating values include:

C Hedonic price model (HPM) – this method imputes the value of such things as differential hazard exposure, or differential mitigation effectiveness from the value of property in an area. Controlling for all other factors, housing prices will vary in relation to how buyers and sellers value the differential hazard exposure. For example, the value of greater earthquake resistance in a house is given by the premium a buyer would pay for this house over another, otherwise identical, house. Through their location decisions, and willingness to pay for alternative locations, people are purchasing bundles of mitigation services that can be valued via the HPM.

C Travel cost model (TCM) – this method calculates the value of some resource, service or commodity by imputing the willingness to pay for increments in the quantity through the willingness to incur costs to travel to the site, as opposed to other sites. Controls are included to remove the effects of different amenities at each site in an attempt to isolate the variation in travel costs. There are many theoretical limitations and criticisms of this methodology, however it remains an accepted means of estimating certain values.

C Contingent valuation method (CVM) – this method uses stated preferences, as opposed to revealed preferences, to impute the value of changes in non-marketed goods and amenities. The basic validity of the method is accepted, both by governments (NOAA report, 1993) and environmental economists. However the devil is in the details, and much remains to resolve issues of validity, reliability and accuracy. Despite these issues, the method has established itself as the primary vehicle for estimating non-market and passive use values. The trend most recently, however, appears to combine both a revealed preference method (such as TCM or HPM) with the CVM to allow comparison and calibration of estimates.
C Benefits transfer method (BT) – While not exactly a method of measuring benefits and costs, it is a method by which estimates of values from other, related, studies can be “transferred” to the current study. This involves understanding the similarities and differences between the original study and the values required for the current study. This method is still in its early stages of development.

Describe the Data Needed to Establish Attribute Value

Data requirements are generally method-determined. The current literature in applied economic analysis can inform us on what data are required at a minimum, and what data are desirable to obtain if available, or affordable for each method. Direct observation of prices is basic to BCA, and survey data serve most indirect measurement methods.

Describe Appropriate Sampling Methods (see Chapter 5 of this report)

Existing data can presumably be used at relatively low cost, other than processing costs, as new data are very expensive to obtain.

Directions for Contractor in Phase II

The appropriate application of BCA in each rack/part is:

1. Track A (Projects)

   After optimal stratified random sampling of the many (000s) FEMA HMGP projects, the contracts will:

   a. Define and identify all relevant project life benefits and costs. This should include a broad definition of standing across spatial dimensions of:

      i. Community
      
      ii. State
      
      iii. National and temporal dimensions (5 years, 10 years, 25 years, 100 years).

   b. The contractor will collect a coherent set of project characteristics for each project to include. The contractor will collect a coherent set of project characteristics for each project to include:

      i. Stratification variables
      
      ii. Community size
      
      iii. Community income
      
      iv. Presence of “spark plug”
c. The contractor will define and calculate a measure(s) of project success.

d. The contractor will perform an empirical analysis of the data to determine the relative impact of project characteristics on project success measures.

2. Track B

The contractor will undertake a more detailed BCA on selected study communities. The standard BCA will be enhanced by acknowledging, defining, and including where possible the following:

a. Indirect impacts such as business disruption.

b. Indirect impacts such as morbidity, mortality, mental health/stress, reassurance.

c. Indirect impacts such as cultural, social, and environmental values.

d. Secondary impacts separated by space/geography and time.

e. The distributional impacts of the benefits and costs of mitigation activities.

f. The cross-effects of multiple projects in one community and of projects generating benefits and costs for multiple hazards.

In Part B, the contractor shall outline the elements of a comprehensive BCA. Specifically, the contractor shall outline and provide justification for each of the following decisions:

a. Those with standing by space/geography and time.

b. The relative weights for those with standing in net benefit calculation (distributional issues).

c. Identify and define all impacts, catalogued as benefit or cost, and select metric for each.

d. If analysis is forward-looking, then predict all step 3 impacts.

e. The monetization of all step 3 impacts.

f. The choice of discount rate.

g. The sensitivity of BCA calculations to particular values chosen in the steps of the analysis.

**Terminology**

The Congressional Charge includes the language: “to assess the future savings resulting from the various types of mitigation activities.” It only identifies savings. But semantically any broad definition of savings would include direct and indirect benefits, and costs/losses avoided, both monetary and nonmonetary. Which brings up the issue of terminology in our document. The
terms costs, losses, benefits, and savings are used in the charge, the Phase I document, and Benefit/cost Analysis literature. To avoid possible ambiguity, these terms and the relationships between them need to be defined:

C Cost – Any reduction in utility or well-being to an individual, group or society associated with an action or choice. Generally it is not the same as price, which bounds cost from above.

C Benefit – Any increase in utility or well-being to an individual, group or society associated with an action or choice. Bounded from below by price. It is synonymous with value in economic theory. Benefits and costs are complementary—a cost is a negative benefit, since costs decrease well-being and benefits increase well-being. This is the source of much confusion in BCA, since different accounting methods will assign the same impact as a benefit or a cost. It is also the source of double counting and should be avoided. Why identify them separately? Because benefits and costs usually are separated by individuals over space and over time.

C Loss – Any reduction in value, or well-being to individuals, groups or society. A loss is a cost. Losses avoided are benefits.

C Saving – Formally saving is the reduction in present consumption to increase future consumption. It defers benefits from the present to the future, and consequently allows temporal shifting of benefits. However, in some contexts, the word is used to mean losses avoided, so implying a benefit.

If we choose to use these definitions, then there really is only ONE thing we have to measure—the change in well-being, or utility, or benefit to members of the society, groups or the whole. Let’s put the group thing to rest: it’s an aggregation issue, that while not trivial, or unimportant, can be treated separately from, and subsequent to, the issue of measuring changes to individual’s welfare.

Benefit Cost Analysis (BCA)\(^1\) is the appropriate “baseline” method to measure future savings from mitigation activities since it has as its theoretical foundation the concepts of economic (Pareto) efficiency, and well-being (welfare or utility) maximization. BCA is not equivalent to wealth maximization, however particular objective functions can produce a BCA consistent with wealth maximization. It is also important to keep in mind that BCA is a method to calculate program net benefits, but offers no guidance, per se, regarding the correct decision to make with the results of the analysis.

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\(^1\) The dominant terminology is Cost Benefit Analysis (CBA), but I prefer to use Benefit Cost Analysis. While this is primarily a matter of personal choice, and not intended to produce confusion, Zerbe and Dively (1994, page 1) make a distinction between the two, claiming that BCA is the term “more closely identified with the earlier development of this approach that recognized the relationship of benefit/cost analysis to important questions of ethics and values and to interesting questions of economic theory,” whereas CBA is “more identified with the use of this technique by engineers in a more mechanistic fashion.”
Appendix D

A Conceptual Approach to Estimating Costs and Benefits from Process Mitigation Activities

Introduction

Members of the Panel on Assessment of Savings from Mitigation Activities prepared background documents to focus panel discussions on particularly vexing issues. Dr. Carol Taylor West drafted this paper with assistance from Kathleen Tierney, David Godschalk, and Tom Tobin. This group was asked to describe a conceptual approach to estimate future savings from process mitigation activities. This approach will be refined and used by the Phase II contractor.

Types of Process Mitigation Activities

In general, “process mitigation activities” are distinguished from “project” mitigation by not having a finite time to completion—rather, there is some ongoing aspect to their nature. In terms of evaluating costs and savings, it is useful to think in terms of three types of process mitigation activities:

1. Initial overhead analyses, planning, education and coordination. These include assessing vulnerability to and risk of hazards, a basic community and political leadership awareness program (workshops, pamphlets, etc.), institutional establishment of hazard research and planning groups, including citizen committees. While this may be a well-defined one-time activity, its ongoing aspect is as an input to and facilitator of future specific community mitigation actions.

2. Updating overhead analyses, planning, education and coordination. As scientific measurement of vulnerability and risk improve, political leadership changes and the resident base of the community evolves, updating of the Item 1 initial analysis becomes necessary.

3. Specific ongoing mitigation strategies. These include land use planning and implementation, building code planning and implementation and emergency coordination plans (e.g., evacuation routes and procedures, early warning procedures, strategies for “calling up” reinforcements).

In evaluating benefits, the important distinction between Items 1 and 2 versus Item 3 is that the former two need to be evaluated in the context of an entire community mitigation program –
these are overhead inputs that contribute to realizing the benefits of all specific strategies, both process strategies like those in Item 3 and project strategies.

**Relevant Costs and their Measurement**

Costs of overhead analyses, planning, education and coordination will vary with community size and the nature and magnitude of the risk hazard. Costs of the scientific analyses should be determined from relevant professionals who perform such studies. Costs of establishing (and maintaining) political leadership and community awareness should be available from historical FEMA process mitigation grants, *Project Impact* grants and potentially, some survey of community mitigation offices.

Potential costs of specific process mitigation strategies (Item 3 above) are three-fold. First, *design and adoption costs* can be expected to have a large variation—relatively low in a situation involving the noncontroversial activity of a professional unit (e.g., a decision of the National Park Service for ongoing clearing of brush in a region), but potentially high if controversial and complex zoning and building code issues are involved in a community. The difficult cost issue arises in the situation of substantial input of citizen time, raising the question of the value of that time.

Second, *public enforcement/implementation costs* are important because they are ongoing with certainty in the case of a process mitigation strategy. These include salary for public personnel who would not be employed without the program (e.g., additional building inspectors), partial salaries for existing public personnel re-assigned to the program, equipment and supplies used in the program, costs of conducting periodic tests or planning sessions in the case of emergency coordination.

Third, there may be *private costs* associated with meeting new codes or land use plans. In the former case, it is the construction cost of conforming to the code.\(^1\) The land use case is more difficult since it depends upon whether or not the private value of development is reduced by the planning.

**Relevant Benefits and their Measurement**

Many process mitigation activities do not have direct benefits. Rather, these are fixed input costs to a variety of final process and project mitigation strategies that do yield direct benefits. Arbitrary assignment of the overhead process mitigation costs among final strategies (and hence, implicit assignment of benefits) lacks a sensible rationale. Basically, whether the overhead costs are justified can only be established in an aggregate analysis of a community’s mitigation strategies. Benefits of the latter are combined to cover not only their individual direct costs combined, but also the overhead costs.

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\(^1\) Note that who ever ultimately pays the cost, the builder or purchaser, is irrelevant. Conforming to a code may also result in a reduced insurance premium. However, the latter should not be netted against the private cost. To do so would double count the expected loss savings the insurance premium change reflects.
Measuring benefits of specific process mitigation strategies is most difficult in the case of emergency coordination plans. Establishing comparable “with” and “withouts” is difficult to envision. Historical comparisons are one potential source—the experience of a community under one hazard without the coordination and the experience of the same community (or similar community) under another hazard with the coordination. The potential comparison is marred by the fact the two historical natural hazards will likely differ in critical dimensions even if of the same broad type (e.g., flood, hurricane, wildfire, earthquake). Computer simulation models, useful for estimating expected loss changes as a consequence of reducing regional vulnerability through changes in the geophysical nature of structures at risk, generally do not address the coordination issues. Some specialized existing emergency response simulation models are available (e.g., some of the studies by Adam Rose and colleagues on optimal restoration of electricity lifelines). However, each is highly incident and location specific, rendering generalization difficult. Are ex post “what ifs” feasible? For example, knowing the prevailing weather conditions, is it possible to estimate what a specific wildfire loss would have been without the coordination that moved firefighters quickly from around the region (country) into the hazard-impacted area to fight the fire?

Land use planning and building code process mitigation strategies are essentially ongoing project mitigation and the benefits can be calculated analogously to project-specific cases. The only twist is to take into account timing. For example, building codes may be applied only to new structures (and perhaps to existing structures only at a critical point in their lifetime such as when it is time for re-roofing). The benefit calculation then has to be based on a specific forecast of community development. For example, suppose the code applies to new single-family residential homes. At a minimum, a long-term (15-25 years) forecast of annual household growth is needed. That can be coupled with a stock accounting-housing model to generate a time sequence of homes meeting the code and the proportion of single-family housing stock meeting code.\(^1\) Average annual hazard losses without code are modified by the proportion meeting code to derive the “with” and “without” scenarios needed for the benefit calculation.

Suggested Approach for Phase II

1. Develop overhead process cost schedules/case studies. These vary by community size, hazard type and vulnerability/risk. An explicit cost schedule may not be feasible, but case studies from sources noted above (FEMA process mitigation grants, Project Impact grants) augmented by input of scientific personnel who do the basic vulnerability/risk studies and some survey of regional process overhead mitigation personnel should yield at least a chart giving illustrative figures by community size, hazard type, vulnerability/risk.

2. Research the feasibility of estimating benefits from coordination/planning process mitigation strategies using comparative case studies and “what ifs” presented to experts. (Potential difficulties are discussed in the second paragraph of the section on Relative Benefits and their Measurement, above).

\(^1\) A stock accounting housing model specifically accounts for allocation of households by type of residency – single-family, multifamily, mobile home – allowing for a normal vacancy rate, replacement stock generated by demolitions and conversions, and in some areas, change in seasonal housing units not occupied by area residents.
3. Use a “semi-hypothetical” case study methodology to illustrate and refine the forecast time benefits of land use planning and building codes as discussed in the last paragraph of the previous section. The semi-hypothetical approach uses actual regions and disaster risks, but hypothetical mitigation strategies.

4. Using a combination of case studies and surveys of professionals, develop the implementation/execution costs and private costs of the semi-hypothetical strategies in Item 3 above and, to the extent feasible, the design/ adoption costs.

5. Coordinating with other parts of the study, develop several complete “mitigation model” semi-hypothetical community case studies. These will include estimates of overhead process activities, all direct costs of the hypothetical strategies (including implementation/execution costs of process strategies), estimated benefits of the strategies and a community aggregate cost/benefit summary. The idea is to have the “big picture” laid out in terms of a chart of community phases of mitigation activities from the initial overhead process ones to final explicit project and process mitigation strategies with numerical values attached to each and an accounting procedure for linking them.

6. Two issues raised in earlier sections—the value of time donated by citizens (second paragraph of the section on Relevant Costs and their Measurement) and private costs of land use planning (last paragraph of the section mentioned above)—have large debates in the literature elsewhere that leave the basic question unanswered. It does not seem reasonable to focus energy of this project on those long-unresolved issues. They can be treated with some sensitivity testing of extremes. Similarly, this process mitigation phase of the project should focus on fundamentals of process as distinct from project mitigation. Issues potentially applicable to both (e.g., indirect as opposed to direct savings should be treated again in a sensitivity analysis using simple multiplier assumptions).
Appendix E

Alternative Decision-Making Tools

Introduction

Members of the Panel on Assessment of Savings from Mitigation Activities prepared background documents to focus panel discussions on particularly vexing issues. Dr. David Godschalk drafted this paper with assistance from Phil Ganderton, Klaus Jacobs, Daniel Sarewitz and Tom Tobin. This group was asked to describe an approach to measure the effectiveness of mitigation activities in achieving multiple objectives. The Phase II contractor will develop this approach in more detail and use it to supplement benefit/cost analyses.

Background Issues

While apparently a simple task, measuring the effectiveness of mitigation activities raises a number of conceptual and methodological issues:

1. Should the analysis of mitigation activities focus on individual hazard (e.g., hurricane, earthquake, flood) mitigation or multihazard (combined hurricane/earthquake/flood) mitigation?

   While analysis of individual hazard mitigation measures may be more feasible to conduct, it is less realistic since most communities necessarily deal with multiple hazards. Any practical analysis should recognize both the positive and negative cross impacts of mitigation measures that are applied in areas subject to multiple hazards (e.g., elevation of structures may minimize flood damage but aggravate wind damage).

2. Should risk management measures (disaster assistance, insurance, etc.) be analyzed as well as mitigation measures?

   To be responsive to the request by Congress for this study, the analysis should focus primarily on mitigation measures. Again, however, in practice most at-risk communities, businesses, and households rely on both mitigation and risk management measures. Thus, for the overall calculation of mitigation costs and benefits, it would be useful to compare the cost of mitigation with the cost of applying risk management to cases of repeated damage loss over time. For example, compare the cost of relocating structures from the 100-year flood plain with the cost of providing emergency assistance, insurance payouts, and the like for repetitively damaged structures.

3. How can hazard modification, hazard avoidance, and hazard resilient engineering measures be compared and determined to be feasible?
It should be possible to measure and compare all three types of measures in terms of the probable risk reduction achieved by each. Sensitivity analysis should be used to provide a comparison that policy makers will find useful.

4. How should measurement deal with issues of scale (federal, state, local) and equity?

The contractor should include all three levels of government in the analysis and should recognize that there are important questions of equity (e.g., who should pay for state and local mitigation) involved. Because the costs of mitigation are shared between different levels of government, it will be necessary to identify the breakdown of assumed costs and benefits in a comprehensive fashion.

5. Can benefits be normalized in terms of assets in order to account for time and discount rate?

The contractor should account for the normalization of benefits and costs over time.

6. Isn't effectiveness measurement primarily suited to decisions about future options, rather than monitoring past performance?

Our charge is to look at future savings, though this will necessarily involve evidence from mitigation measures applied in current and past disasters. The analysis should recognize the intrinsic difficulties of achieving precision concerning future savings, given the difficulty of validating estimates of uncertainty.

7. What is the appropriate geographic unit of analysis – the political jurisdiction (the city, county, or state) or the natural feature (the earthquake fault, the river basin, the regional flood plain, the shoreline, etc.)?

Both scales are relevant for mitigation analysis. Political jurisdictions are the locus of most mitigation program activities and the standard way of reporting damage, providing emergency assistance, and the like. However, analyzing natural features that cross-jurisdictional boundaries allows the analyst to look at the entire hazard area and possibly to discover more cost effective mitigation actions (e.g., comparing restoration of original riverine flood plains with the cost of maintaining levees).

8. What methods should be used for multi-attribute decision analysis?

This is a significant matter for the contractor to consider. The core of this charge is to work out a methodological alternative that overcomes the limitations of cost benefit analysis.

9. Is it useful to distinguish between the "possibility" and the "probability" of a hazard occurrence?

This distinction was made by one of the authors of a study cited in the literature. It may or may not be useful in the final approach to be utilized. It may well be simply a semantic, rather than an actual, distinction.

10. How can a weighting system be devised to include both monetary and non-monetary outcomes?
This is the claim of cost utility analysis, which attempts to measure outcomes in terms of weights assigned by professionals and stakeholders. This is probably the most difficult methodological challenge for the contractor. Yet it is probably also the most important need if the measurement of effectiveness is to be persuasive.

**Existing Methods**

Levin and McEwan (2001, Table 1.5, pp. 27-28) identify four types of cost analyses and their primary characteristics:

C Cost effectiveness asks which alternative yields a given level of effectiveness for the lowest cost or the highest level of effectiveness for a given cost?

C Cost benefit asks which alternative yields a given level of benefits for the lowest cost, or the highest level of benefits for a given cost, and is the benefits of a single alternative greater than its costs?

C Cost utility asks which alternative yields a given level of utility at the lowest cost or the highest level of utility at a given cost?

C Cost feasibility asks if a single alternative be carried out within the existing budget?

Given our charge, it appears that types 1 and 3 are the most relevant for us to consider. Both of these measure cost in terms of the monetary value of resources to be spent. However, cost effectiveness measures outcomes in terms of units of effectiveness and cost utility measures outcomes in terms of units of utility. Neither is required to measure outcomes in terms of the monetary value of benefits, a major difficulty in cost benefit analysis. (Note that both still depend on quantitative analysis and rely on predictions of future conditions, as opposed to more qualitative assessment approaches.)

Effectiveness measures look at two or more alternative actions with similar objectives. For example, one might measure the effectiveness of elevation and acquisition in reducing property damage to houses in the 100-year flood plain.

Actions with different objectives have different indicators of effectiveness, and cannot be compared under cost effectiveness analysis. Measures are said to be reliable if they yield the same result when applied over time, and to be valid if they correspond to the concept they are representing.

When there are multiple outcomes of significance, the intended and unintended outcomes of each alternative should be measured. A separate cost effectiveness analysis could be done for each measure. For example, one might also measure the effectiveness of elevation and acquisition in reducing fatalities to residents of the 100-year flood plain.

Uncertainty can be dealt with through sensitivity analysis or decision trees. Sensitivity analysis estimates cost effectiveness ratios over the range of variation of a particular uncertain parameter. High and low ends of the range may be derived by professional judgment or by a statistical confidence interval. The decision tree multiplies the possible outcomes of alternatives by their probabilities, and compares the results.
Another approach to analyzing multiple measures is to conduct a cost utility analysis. Here multiple measures of effectiveness, weighted by their importance to stakeholders, are combined into a single summary measure of utility. Weights can be estimated or elicited from stakeholders. The technical name is multi-attribute utility theory, and the tool is the multi-attribute utility function, which is the sum of the single-attribute functions (converted into a common utility scale) multiplied by their importance weights. Probabilities can be incorporated into this technique, using a decision tree.

O'Brien (2000, p. 147) proposes alternatives assessment as a counterpart to cost benefit analysis. In her terms, alternatives assessment can be installed as a sensible three-step public process for making decisions about all behaviors that affect the environment:

C Consider a range of reasonable alternatives.
C Discuss the potential environmental, public health, and social benefits of each alternative.
C Discuss the potential adverse environmental, public health, and social impacts of each alternative.

Applying the O'Brien alternatives assessment to hazards would allow discussion of the widest range of benefits and impacts. For example, while acquisition/relocation has clear benefits in terms of reducing exposure of people and property to hazards, it also has some potential adverse impacts in terms of breaking up established neighborhoods and social groupings.

Ashford and Caldart (1991; cited in O'Brien) speak of tradeoff analysis. Ashford (1993; cited in O'Brien, p. 154) describes technology options analysis in testimony about chemical accidents. He distinguishes between primary prevention to develop inherently safer technologies that prevent the possibility of an accident, secondary prevention that reduces the probability of an accident, and mitigation and emergency response to seek to reduce the seriousness of injuries resulting from accidents.

The Ashford framework might be applied to hazard mitigation. Thus you could compare:

C Comprehensive mitigation techniques that prevent the possibility of human injury or property damage (moving people out of hazard areas)
C Partial mitigation techniques that reduce the probability of injury or damage (strengthening structures) and
C Techniques that reduce the seriousness of impacts resulting from hazards (emergency preparation and response) or the household's or business' cost of recovery (insurance).

Recommendations

The Phase II contractor should conduct a parallel analysis to his/her benefit/cost studies, in order to compare the results with those of alternative approaches. These alternative approaches should include either applications of the following individual approaches or a "hybrid" approach that includes their key features:
C Cost effectiveness analysis

C Cost utility analysis

C Alternatives assessment

C Technology options assessment.

In order to illustrate the power and usefulness of these alternative analytical approaches, this parallel analysis should be applied to as many of the mitigation techniques, disasters, and cases as possible. It should include both retrospective and prospective applications. The parallel analysis should identify, discuss, and compare the results of the contractor's cost benefit analyses with those of the alternative approaches. It should recommend the types of situations in which one or more of the alternative approaches would be preferable to cost benefit analysis, and should outline a practical methodology for applying the desired alternative approaches. To the extent possible, it should include assessments of the accuracy of prior attempts to predict future savings from hazard mitigation or other analogous areas of public policy.
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